



TITLE:

Abstracts

AUTHOR(S):

CITATION:

Abstracts. Wood research : bulletin of the Wood Research Institute
Kyoto University 1997, 84: 174-221

ISSUE DATE:

1997-09-30

URL:

<http://hdl.handle.net/2433/53202>

RIGHT:

Abstracts

Gene expression of endo-1, 4- β -glucanase in suspension cultured poplar cells, T. TAKEDA, F. SAKAI and T. HAYASHI: *Bosci. Biotech. Biochem.*, **61**, 907–908 (1997).

The level of mRNA for endo-1, 4- β -glucanase was increased before the exponential phase of growth and decreased rapidly during the exponential phase in suspension-cultured poplar cells. The level of mRNA was increased for a short period after the addition of either 2, 4-D or sucrose to the culture medium at the stationary phase. The level was increased to the maximal level when both 2, 4-D and sucrose were provided together, but one did not increase the effect of the other. These findings suggest that expression of gene encoding poplar endo-1, 4- β -glucanase is controlled during cell growth by independent systems activated by auxin and sucrose.

Changes in levels of mRNAs for cell wall-related enzymes in growing cotton fiber cells, Y. SHIMIZU, S. AOTSUKA, O. HASEGAWA, T. KAWADA, T. SAKUNO, F. SAKAI and T. HAYASHI: *Plant Cell Physiol.*, **38**, 375–378 (1997).

mRNAs for cell wall-related enzymes in developing cotton fiber cells were measured by reverse transcription-PCR analysis. Both endo-1, 4- β -glucanase and expansin mRNA levels were high during cell elongation but decreased when cell elongation ceased, and xyloglucanase decreased. The endo-1, 3- β -glucanase mRNA level was very low in the elongating cells but increased gradually at the onset of secondary wall synthesis, accompanying the massive deposition of cellulose. Endoxyloglucan transferase and sucrose synthase mRNA levels were constant during all stages of growth.

Promotion of pea stem elongation by the fragments of plant cell wall polysaccharides, Y. SHIMIZU, T. HAYASHI, T. KAWADA and T. SAKUNO: *Mokuzai Gakkaishi*, **43**, 121–127 (1997).

Effects of cell wall polysaccharides on the elongation of pea stem were demonstrated.

Purification of xyloglucanase from auxin-treated pea stems, T. MATSUMOTO, T. TAKEDA, F. SAKAI and T. HAYASHI: *Wood Research*, **83**, 21–22 (1996)

The purification of xyloglucanase from auxin-treated pea stems was shown.

Xyloglucan endotrans-glycosylation in suspension-cultured poplar cells, T. TAKEDA, Y. MITSUISHI, F. SAKAI and T. HAYASHI: *Biosci. Biotech. Biochem.*, **60**, 1950–1955 (1996).

Xyloglucan endotransglycosylase activity was identified and defined by transfer of a part of xyloglucan to [^3H]XXXGol in suspension-cultured poplar cells. Although the activity was distributed in buffer-soluble and -insoluble fractions associated with cells and in

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extracellular fraction, it was mostly recovered as the buffer-insoluble fraction, suggesting the binding of the enzyme to cell walls. The molecular size of donor xyloglucan for maximal incorporation seems to be attained between 40 kDa and 120 kDa. The affinity for acceptor XXXGol were increased in higher concentrations of donor xyloglucan with a constant V_{max} value. The V_{max} values for donor xyloglucan were increased in higher concentrations of the oligosaccharide without changing affinity. These kinetic data suggest that acceptor acts by combining independently of the donor with the enzyme. The velocity of the reaction was decreased gradually as the heptasaccharide units increased from two to four, suggesting that the xyloglucan endotransglycosylase reaction caused donor xyloglucan substantially to decrease its molecular size. The activity was enhanced by ABA but depressed by GA_3 in auxin-starved cells, when cultured in MS medium containing various plant hormones. Nevertheless, the activity increased markedly at the exponential growth and decreased immediately at the stationary phase of cells in the presence of 2, 4-D. It is likely that the activity of xyloglucan endotransglycosylase is developmentally regulated during growth rather than direct induction by plant hormones.

Observation for cell wall architecture, T. HAYASHI and T. ITOH: *Cell Technology*, **6**, 146–154 (1997).

Observation techniques for cell walls were shown and reviewed.

Expression of stilbene synthase gene in Japanese Red Pine (*Pinus densiflora*) seedlings, K. KUBOTA, H. KURODA and F. SAKAI: *Wood Research*, **83**, 17–20 (1996).

Stilbene synthase gene was expressed under stress in Japanese red pine seedlings. The distinct expressions were studied in two phenotypes.

Stilbene synthase gene from Japanese Pine Trees, Its implication in Pine Wilt diseases, H. KURODA and F. SAKAI: *Proceedings of the First International Wood Science Seminar*, **44**, Kyoto, Dec. 6–7 (1996).

Authors proposed hypothesis that stilbene synthase gene works as a defense factor to pine wilt diseases.

Suppressive effect of L-phenylalanine on manganese peroxidase in the white-rot fungus, *Phanerochaete chrysosporium*, Y. AKAMATSU and M. SHIMADA: *FEMS Microbiology Letters*, **145**, 83–86 (1996).

The effect of added L-amino acids and NH_4^+ on manganese peroxidase activity in ligninolytic cultures of *Phanerochaete chrysosporium* were investigated. Among 11 amino acids (0.2 mM) tested, including phenylalanine, glutamate, glutamine, histidine, alanine, isoleucine, ornithine, glycine, aspartate, proline, and arginine, phenylalanine was the most effective in suppression of manganese peroxidase synthesis. However, all the amino acids tested except proline completely suppressed the enzyme synthesis at 2 mM concentration.

Occurrence of enzyme systems for production and decomposition of oxalate in a white-rot fungus *Coriolus versicolor* and some characteristics of glyoxylate oxidase, K. MIY, T. HATTORI and M. SHIMADA: *Wood Research*, No. **83**, 23–26 (1996).

The occurrence of glyoxylate oxidase, formate dehydrogenase, and also oxalate decarboxylase in the white-rot fungus *Coriolus versicolor* and some characteristics of the glyoxylate oxidase were reported.

Recent advances in research of lignans, T. UMEZAWA: *APAST*, No. **20**, 15–19 (1996) (in Japanese).

Recent advances in studies of wood extractives, especially lignans, were reviewed.

Biological activity and biosynthesis of lignans, T. UMEZAWA: *Mokuzai Gakkaishi*, **42**, 911–920 (1996) (in Japanese).

Recent advances as well as historically important papers in the field of chemistry, biological activities, and biosynthesis of lignans were reviewed.

Lignans, T. UMEZAWA: In “Springer Series in Wood Science, Biochemistry and Molecular Biology of Wood” (Ed. Higuchi, T.), Springer-Verlag, Berlin, pp. 181–194 (1997).

Recent advances as well as historically important papers in the field of stereochemistry and biosynthesis of lignans were reviewed.

New cellulose synthesizing complexes (=terminal complexes) involved in animal cellulose biosynthesis in the tunicate, *Metandrocarpa uedai*, S. KIMURA and T. ITOH: *Protoplasma*, **194**, 151–163 (1996).

Cellulose synthesizing enzyme complexes (=TCs) have been found in the plasma membrane of epidermal cells in the tunicate, *Metandrocarpa uedai*, by using freeze-fracture replication techniques for electron microscopy. Assembly of cellulose microfibrils by TCs is a universal phenomenon in the biological kingdoms. The TCs are locally distributed in the plasma membrane of the epidermal cells facing the tunic, and no TCs are observed on the lateral membranes bordered by tight junctions. The TCs consist of two types of membrane subunits: large particles (14.5 nm in diameter) on the periphery and small subunit particles (7.2 nm) filling the center; the latter are hypothesized to be involved in cellulose synthesis. The TCs are the linear type (ca. 195 nm in length and 78 nm in width). Direct connections of TCs with the termini of microfibrils were observed. Amorphous regions, which were hypothesized the nascent microfibrils, were associated with the depressions of the TCs. The distortion of microfibrils on their terminus indicates that the crystallization may occur at the margin of TCs from which the microfibrils are discharged. This report provides evidence that: (1) The outer cell membrane of epidermis is the site for the assembly of cellulose microfibrils in the tunic; (2) a new type of TC is involved in the biosynthesis of

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cellulose microfibrils in the tunicates; (3) disorganized glucan chains may be synthesized in the depression of TCs and crystallized outside the E-surface of the epidermal cell membrane.

A new site for cellulose biosynthesis in tunicates, S. KIMURA and T. ITOH : *Electron Microscopy*, **31**(1), 59–61 (1996) (in Japanese).

A glomerulocyte that is differentiated from epidermal cells in *Metandrocarpa uedai* has been found to have an ability of cellulose synthesis. The mechanism how cellulose microfibrils are synthesized in the glomerulocyte is presented and reviewed as follows: (1) Introduction, (2) glomerulocyte and fibrillar structure in a vacuole, (3) the mechanism for the formation of cellulose bundles and (4) conclusion.

Recent progress of cellulose biosynthesis, T. ITOH : *Seni Gakkaishi*, **53**(1), 20–25 (1997) (in Japanese).

The recent progress of cellulose biosynthesis in a variety of organisms including higher plants, algae, animals, protists and bacteria has been reviewed as follows: (1) Introduction, (2) biosynthesis of cellulose, (3) crystallization of cellulose microfibrils and membrane structure, (4) two cellulose-synthesizing sites in tunicates, and (5) conclusion.

Anatomical description of Japanese hardwoods I, T. ITOH : *Wood Research and Technical Notes*, No. **31**, 81–181(1995) (in Japanese).

The anatomical characteristics of Japanese hardwoods classified from Casuarinaceae to Moraceae covering 80 species, among 35 genera and 11 families are described. The photomicrographs of cross, radial and tangential sections covering 80 species are also presented.

Anatomical description of Japanese hardwoods II, T. ITOH : *Wood Research and Technical Notes*, No. **32**, 66–176 (1996) (in Japanese).

The anatomical characteristics of Japanese hardwoods classified from Urticaceae to Pittosporaceae covering 87 species, among 56 genera and 24 families are described. The photomicrographs of cross, radial and tangential sections covering 87 species are also presented.

Fine structure and tensile properties of ramie fibers in the crystalline form of cellulose I, II, III_I, and IV_I, A. ISHIKAWA, J. SUGIYAMA and T. OKANO : *Polymer*, **38**, 463–468 (1997).

The tensile properties of ramie cellulose I, II, III_I, and IV_I were examined by introducing mechanical models. On the basis of the series model, Young's modulus of crystalline component of cellulose III_I was the highest and the next was that of cellulose I, followed by II and IV_I. Young's modulus of amorphous component of cellulose I was the highest and the next was that of II, followed by III_I and IV_I. Applying a parallel-series

model, the values for Young's moduli of crystalline and amorphous components were found to depend both on the feature of crystalline component and the density of amorphous region.

Cellulose structure and its implication to biological diversity, J. SUGIYAMA : *Wood Research and Technical Notes*, No. **32**, 16–22 (1996) (in Japanese).

The updated knowledge on the structural variation of cellulose microfibrils, such as dimensions, twisting, crystalline allomorphism and crystal orientation, were briefly summarized. Also the possible cause of such variations was discussed in relation to the mechanism of biosynthesis.

TENCEL®, J. SUGIYAMA : *APAST*, No. **23**, 16–19 (1997) (in Japanese).

TENCEL, new regenerated cellulosic fiber from the melt of wood pulp, was reviewed with special reference to its production, physical properties, solvent system and marketing.

Chemical and Anatomical Characterization of the Tension Wood of *Eucalyptus camaldulensis* L., K. BABA, T. ONA, K. TAKABE, T. ITOH and K. ITO : *Mokuzai Gakkaishi*, **42** (8), 795–798 (1996).

Tension wood of *Eucalyptus camaldulensis* L. was characterized chemically and anatomically. Contents of cellulose and extractives were more and those of lignin and hemicelluloses were less in the tension wood than those in normal wood. Tension wood was characterized by gelatinous fibers, small microfibril angles, long fiber length, and reduced vessel frequency. The cell wall type of fiber secondary walls in tension wood was classified to be the Type S₁+G.

Production and characterization of ligninolytic enzymes of *Bjerkandera adusta* grown on wood meal/wheat bran culture and production of these enzymes using a rotary-solid fermenter, S. YOSHIDA, S. YONEHARA, S. MINAMI, H.-C. HA, K. IWAHARA, T. WATANABE, Y. HONDA and M. KUWAHARA : *Mycoscience*, **37**, 417–425 (1996).

Manganese peroxidase (MnP) and lignin peroxidase (LiP) were produced by growing a white-rot fungus *Bjerkandera adusta* statically, on a wood meal/wheat bran culture in flasks. MnP and LiP reached their maximum activity after 6 and 19 days of inoculation, respectively. Both MnP and LiP are thought to be important enzymes in lignin biodegradation by *B. adusta*. Ion exchange chromatography showed that *B. adusta* produced a single LiP and a single MnP enzymes in wood meal/wheat bran culture. These enzymes were separated and characterized. The molecular weight of MnP was 46,500 with a pI of 3.9. The molecular weight of LiP was estimated to be 47,000 with a pI of 3.5. Spectral analysis demonstrated that both enzymes are heme proteins. Production of these enzymes was also achieved using a rotary-solid culture fermenter. MnP, LiP and veratryl alcohol oxidase were produced by *B. adusta* in the fermenter.

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Reaction of chemically modified lignin peroxidase of *Phanerochaete chrysosporium* in water-miscible organic solvents, S. YOSHIDA, T. WATANABE, Y. HONDA and M. KUWAHARA : *Biosci. Biotech. Biochem.*, **60**, 1805–1809 (1996).

LiP of *Phanerochaete chrysosporium* was chemically modified with MPSS, and acetic and benzoic acid N-hydroxysuccinimide esters to increase the activity in organic solvents. IEF demonstrated the LiP was chemically modified with these modifiers. The modification of LiP was also confirmed by GFC and anion-exchange chromatography analyses. In addition, the modified LiP retained its original activity in aqueous solution. Furthermore, these modified LiPs had higher 3, 3'-dimethoxybenzidine oxidation activity than the native LiP in aqueous 70% water-miscible organic solutions including ethylene glycol and diethylene glycol. However, the activities of these modified enzymes were found to be negligibly low in water-immiscible organic solvents such as benzene and toluene. Furthermore, the effects of these introducing groups and the properties of organic solvents on the reaction of LiP in water-miscible organic solvents were investigated. The reaction of LiP modified with aliphatic acid was found to depend on the viscosity of the reaction system containing 70% water-miscible organic solvents. This suggests that the viscosity of the reaction system containing water-miscible organic solvents is important for the reaction of LiP modified with aliphatic acids.

Effects of water-miscible organic solvents on the reaction of lignin peroxidase of *Phanerochaete chrysosporium*, S. YOSHIDA, T. WATANABE, Y. HONDA and M. KUWAHARA : *J. Molecular Catalysis B: Enzymatic*, **2**, 243–251 (1997).

The oxidation of lignin peroxidase (LiP) of *Phanerochaete chrysosporium* was examined using various phenolics and aromatic amines as substrates in organic solvents. LiP oxidized 3, 3'-dimethoxybenzidine more effectively in several 70% aqueous water-miscible organic solvents including ethylene glycol and methylcellosolve than in water. LiP activity in water-miscible organic solvents was correlated with the Dimroth-Reichardt parameter (ET(30)) of the solvents, which is directly related to free energy of the solvation process. In addition, absorption spectra of LiP in several glycols were similar to those in succinate buffer. These results suggest that these glycols do not disturb the conformation around the active center, heme, of LiP. Furthermore, LiP catalyzed the oxidation of several phenolics and aromatic amines including 3, 3'-dimethoxybenzidine, *o*-, and *p*-phenylenediamines and *o*-aminophenol in 70% aqueous ethylene glycol solution. These substrates were shown to have low ionization potential and high hydrophobicity, and thus to be suitable substrates for the reaction of LiP in water-miscible organic solvents.

Lignin peroxidase production by *Phanerochaete chrysosporium* immobilized on polyurethane foam Y. NAKAMURA, T. SAWADA, M.G. SUNGUSIA, F. KOBAYASHI, M. KUWAHARA and H. ITO : *J. Chem. Engin. Japan*, **30**, 1–6 (1997).

Production of lignin peroxidase by a white-rot basidiomycete, *Phanerochaete chrysosporium*, was investigated experimentally using polyurethane foam as a carrier of immobilized fungal mycelia. The immobilized cell culture using polyurethane foam as a carrier of mycelia yielded significantly greater lignin peroxidase activity than the conventional stationary liquid culture. The effects of operational conditions, such as the kind and number of polyurethane foam cubes, glucose concentration and temperature, on the lignin peroxidase production were examined. Addition of 0.05% Tween 80, 1 mM veratry alcohol and 1 mM $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ greatly improved the production of lignin peroxidase up to 2,700 units/ml culture medium. The lignin peroxidase activity in this culture was about three times larger than that obtained from the culture cultivated in the absence of these additives. Step change incubation lowering the temperature from 37°C to 30°C over an incubation time of three days was carried out for the large scale production of lignin peroxidase, and this incubation gave the highest lignin peroxidase activity 3,800 units/ml culture medium.

Digestibility, absorptivity and physiological effects of cellooligosaccharides in human and rats, M. SATOUCHI, T. WATANABE, S. WAKABAYASHI, K. OHKUMA, T. KOSHIJIMA and M. KUWAHARA: *J. Jpn. Soc. Nutr. Food Sci.*, **49**, 143–148 (1996) (in Japanese with English summary).

Physiological properties of cellooligosaccharides produced by cellulase membrane bioreactor was studied. Cellooligosaccharides were resistant to human salivary amylase, artificial gastric juice and porcine pancreatic amylase but partially hydrolyzed by rat intestinal mucosa cell homogenates. The blood glucose level after loading of cellooligosaccharides was gradually increased in rats. However, no increase in the blood glucose level was observed in humans. Insulin secretion was not stimulated by cellooligosaccharides in rats and humans. Excretion into feces after a single ingestion of cellooligosaccharides was not detected in rats. The rats were kept for 4 weeks on a high-sucrose diet or a cellooligosaccharide-supplemented high sucrose diet. At the 4 week, body fat, the serum level of fructosamine, total cholesterol and triglyceride were higher in the high sucrose-fed rats than in the cellooligosaccharide-fed rats. These results suggest that cellooligosaccharides are indigestible oligosaccharides and effective for prevention of diabetes and obesity.

Xylanase-resistant xylan in unbleached kraft pulp, T. WATANABE, K. MIKAME, Y. HONDA and M. KUWAHARA: *J. Wood Chem. Technol.*, **16**(2), 109–120 (1996).

A water-soluble chromophoric xylanase-resistant xylan was isolated from hydrolyzates of unbleached kraft pulp. The xylan contained over 70% of unremovable inorganic atoms together with a trace amount of lignin component abundant in quinoid structures. The fraction was partially decolorized by *Coriolus versicolor* and bacterial microflora without action of extracellular lignin peroxidase, Mn-peroxidase and laccase.

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A dnaA box can functionally substitute for the priming signals in the *oriV* of the broad host-range plasmid RSF1010, Y. TAGUCHI, K. TANAKA, Y. HONDA, D.-M. MIAO, H. SAKAI, T. KOMANO and M. BAGDASARIAN: *FEBS lett*, **388**, 169–172 (1996).

The replication origin of the broad host-range plasmid RSF1010 contains 3.5 copies of a 20mer iteron sequence and two strand specific priming signals, *ssiA* and *ssiB*. These priming signals direct the initiation of DNA replication process which is essential for the normal maintenance of this plasmid and dependent on plasmid-encoded specific primase, RepB'. In this report, the authors demonstrated that a dnaA box, recognition site for the initiator protein of *E. coli* chromosomal replication, DnaA, substitute for the specific priming signals in the plasmid DNA replication via DnaA-dependent manner.

Isolation and characterization of *Pleurotus ostreatus* mutant strains resistant to a carboxin-derived fungicide flutolanil, Y. HONDA, T. IRIE, M. ATSUGI, T. WATANABE and M. KUWAHARA: *Mycoscience*, **37**, 459–461 (1996).

Wood decaying fungi have received considerable attention from various biological and industrial points of view. For instance, the abilities of white rot fungi to degrade plant cell wall lignin and a variety of environmental pollutants, including dioxins and PCBs, have been the focus of intense research interest in the last decade. To elucidate the molecular mechanism of such specific properties, it is necessary to introduce gene engineering techniques, such as cloning, expression, disruption and replacement of a gene of interest, into the biochemical analysis of fungi. To develop a dominant marker in white rot fungus, *Pleurotus ostreatus*, mutant strains resistant to a carboxin-derived fungicide, flutolanil, were isolated. These mutants included strains which showed resistance to 50-fold higher concentration of flutolanil than the wild type strain, even after successive cultivations in the absence of the drug. Dominance of the phenotype was confirmed by back-crossing between the resistant and wild-type monokaryons. The flutolanil-resistance was also shown to stably inherited by the basidiospore-derived progenies of the mutant strains.

Molecular and crystal structure of cellulose propanoate diacetate (CPDA, 2, 3-di-O-acetyl-6-O-propanoyl cellulose), T. IWATA, K. OKAMURA, J. AZUMA and F. TANAKA: *Cellulose*, **3**, 91–106 (1996).

The molecular and crystal structure of cellulose propanoate diacetate (CPDA, 2, 3-di-O-acetyl-6-O-propanoyl cellulose) has been determined through combined X-ray fiber diagrams and electron diffraction patterns of single crystal analysis, aided by stereochemical restraints by using a constrained linked-atom least-squares refinement. The unit cell of CPDA is orthorhombic with space group $P2_12_12_1$ and parameters: $a = 1.239$ nm, $b = 2.498$ nm and c (fiber axis) = 1.044 nm. Based on these data, coupled with the observed density of the crystals, there are four chains per unit cell, distributed in two antiparallel pairs of parallel chains, and the independent repeat is the disaccharide unit in each chain. A

preliminary CPDA disaccharide unit was derived based on the center residue of cellotriose undeca-acetate, and this model was refined through a conformational analysis. The best model obtained by combining the stereochemical refinement with the diffraction intensities gave $R=0.272$ ($R''=0.259$) for the three-dimensional information from the X-ray fiber diagram and $R=0.248$ ($R''=0.246$) for the base plane data resulting from electron diffraction analysis.

Molecular and crystal structure of cellulose acetate dipropanoate (CADP, 6-*O*-acetyl-2, 3-di-*O*-propanoyl cellulose), T. IWATA, K. OKAMURA, J. AZUMA and F. TANAKA: *Cellulose*, **3**, 107–124 (1996).

The molecular and crystal structure of cellulose acetate dipropanoate (CADP, 6-*O*-acetyl-2, 3-di-*O*-propanoyl cellulose) has been determined by using a constrained linked-atom least-squares refinement method, combined with X-ray and electron diffractograms and stereochemical refinement. The diffraction analysis indicated that CADP crystallized in a $P2_1$ monoclinic space group with unit cell parameters: $a=1.088$ nm, b (unique axis) = 1.593 nm, c (fiber axis) = 1.509 nm and $\beta=94.1^\circ$. The best model derived from combining the stereochemical refinement with the diffraction intensities gave $R=0.217$ ($R''=0.195$) for the three-dimensional information from the X-ray fiber diagram and $R=0.198$ for the base plane data resulting from electron diffraction analysis. In the model, crystal structure of CADP consisted of a system of right-handed threefold helices packed in an antiparallel fashion, with two molecules passing through the unit cell.

Conformational analysis of cellulose tributyrate and cellulose trivalerate, T. IWATA, F. TANAKA, K. OKAMURA and J. AZUMA: *SEN'I GAKKAISHI*, **52**, 423–429 (1996).

The single chain conformation of cellulose tributyrate (CTB) and cellulose trivalerate (CVT) has been investigated using MM2 ('87) with Jeffrey's parameter set. The energy surface of CTB had the deepest energy well near twofold screw axis zone. X-ray data supported this result. Two major conformations were found in this energy well. One was just on the twofold screw axis symmetry with fiber repeat distance, and the other existed in the lowest energy area just with exact fiber repeat distance. Evaluating the total energy value and torsional angles of side groups, the latter was found superior to the former. On the other hand, the most stable conformation of CTV was satisfied with all three parameters (twofold axis symmetry, fiber repeat distance and deepest energy well) on the energy surface. Considering the molecular packing from X-ray patterns, we can predict that both structures have twofold screw symmetry along the molecular axis on the center of two chains.

Molecular Dynamics of Cellulosic Polymers, A. SARCO and F. TANAKA: *Forefronts*, Cornell Theory Center, **12**, No. 1, 3-8 (1997).

Owing to its linear, high-molecular-weight polymeric nature, the physical properties of

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cellulose are determined not only by its chemical structure but also by the conformational properties of its physical structure - the shape of the molecule.

In carrying out MD simulation on cellulose, it became clear that special attention must be paid to a number of variables; the size of the model designed to simulate the molecule (i.e., the oligomer fragment), the force field used for modeling, the length of the simulation, and the temperature of the simulation. Additionally, it was desirable to carry out all simulations in vacuum, in solution (e.g., water), and in the solid state, for comparative purposes.

Comparable results were obtained at two temperatures used in these simulations, 300°K and 400°K. Comparable results were also obtained with octamers and hexadecamers.

For the length of the simulations, the initial goals were to extend all runs to 10-ns. Although these length have not been reached yet, it appears that 2-ns simulation run are sufficient in length to allow calculation of octamer and hexadecamer model equilibrium properties.

All simulation trajectories revealed interesting aspects of molecular motions and likely mechanism responsible for the gross changes in the conformation of the molecule.

Future plans include extending the length of the simulations, carrying them out with solutions and a variety of solid states, and including among the models non-hydrogen bonding derivatives. Additionally, simulations with models longer than hexadecamers might be attempted.

Dimensional Stabilization of Wood Composites by Steaming I, Fixation of Compressed wood by Pre-steaming, M. INOUE, N. SEKINO, T. MOROOKA and M. NORIMOTO: *Toward the New Generation of Bio-Based Composite Products*, 240–248 (1996).

Wood block specimens pre-steamed at 120–220°C for 5–20 minutes were compressed by more than 50% of strain in the radial direction. The set recovery decreased with increasing pre steaming temperature and time. The reduction of set recovery correlates well with the amount of weight loss in steaming, irrespective of pre-steaming temperature and time. The weight loss for the perfect fixation of compressive deformation was about 7.5%, which was obtained by pre steaming at 210–220°C for 10 minutes. Moreover, the set recovery of the pre-steamed specimen decreased, as pressing temperature and time increased.

The compressibility of wood block increased with increasing pre-steaming temperature and time. Large transverse compression and stress relaxation tests showed that the Young's modulus and yield stresses were reduced while the stress relaxation magnitude was increased by harsher pre-steaming condition. Under scanning electron microscope observation, some cell structure destruction was observed in the specimen steamed at above 180°C. This shows that the wood becomes brittle due to steaming. By the creep tests,

fluidity was found to decrease with increasing steaming time and temperature. From these facts, it could be deduced that the fixation of compressive deformation by pre-steaming was brought about by the degradation of the microfibril, as well as the viscous flow of the matrix components resulting from the scission of their cross-linked network.

Dimensional Stabilization of Particleboards by Steam Pre-treatment, The Mechanisms Involved, N. SEKINO, M. INOUE, M.A. IRLE and T. ADCOCK : *Toward the New Generation of Bio-Based Composite Products*, 249–257 (1996).

This paper describes work which is part of a systematic study for an understanding of the mechanisms of particleboard dimensional stabilization by steam pre-treatment. The effects of steam temperature on the following factors, which directly or indirectly affect panel thickness swelling were investigated by the use of wood blocks : swelling stress and thickness recovery of compressed wood, hygroscopic swelling and Young's modulus of uncompressed wood, and adhesive bond strength. It was found that the compressibility of the steam pre-treated wood increased with the increasing steam temperature and that the recovery stress of the compressed wood decreased with the increasing compressibility. The thickness recovery of the compressed wood decreased markedly when steamed above 180°C. Steam pre-treating below 200°C did not reduce the adhesive bond strength. Steam pre-treatment reduced wood hygroscopicity, the resultant swelling, and Young's modulus, which implies that there is a possibility for the shear stress imposed on the adhesive bond between chips to be reduced.

Viscoelastic properties of chemically modified wood, M. NORIMOTO : "Chemical Modification of Lignocellulosic Materials", D.N. HON, ed., p. 311–330, Marcel Dekker, Inc., New York·Basel·Hong Kong (1996).

A classification of chemically modified woods is proposed and their viscoelastic properties including creep and dynamic mechanical properties along the grain are presented and analyzed in relation to the type of chemical modification involved.

Analysis of the shrinkage deformation of wood cells using the replica and Fast Fourier Transform methods, U. WATANABE, M. FUJITA and M. NORIMOTO : "Recent Advances in Wood Anatomy", L.A. DONALDSONS, A.P. SINGH, B.G. BUTTERFIELD and L.J. WHITEHOUSE, eds., p. 363–365, New Zealand FPL, Ltd., New Zealand (1996).

The cell shapes in both the wet condition and oven-dry condition were modelled by FFT, and the models in both conditions were used to express the shrinkage deformation of the wood cell. Normal and compression woods of five conifers (*Cryptomeria japonica*, *Chamaecyparis obtusa*, *Picea sitchensis*, *Agathis bornensis* and *Podocarpus imbricatus*) were examined. Coniferous wood with indistinct growth rings, like *Agathis bornensis* and *Podocarpus imbricatus*, showed an anisotropic shrinkage on the transverse surface. It was evident that the

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shrinkage deformation of these cells was anisotropic in itself. The shape of the lumen changed anisotropically, that is, the change in the tangential direction was larger than that in the radial direction. The results indicate that the anisotropic shrinkage on the transverse surface of wood originates primarily from that of the cell and secondarily from other factors such as tree rings. It is suggested that the transverse shape of the cell contributes to the anisotropic shrinkage, especially in cells with a hexagonal shape. It was observed that the included angle between two radial walls became larger during shrinkage; this angle change made the radial wall straighter and the shrinkage quantity in the tangential direction larger.

Shrinkage and elasticity of normal and compression woods in conifers, U. WATANABE and M. NORIMOTO: *Mokuzai Gakkaishi*, **42**(7), 651–658 (1996).

The relationships of shrinkage to the specific gravity or to the Young's modulus were investigated in normal and compression woods of *Cryptomeria japonica*, *Chamaecyparis obtusa*, and *Picea sitchensis* as well as in *Agathis bornensis* and *Podocarpus imbricatus* which are tropical conifers. The darkly colored portions of *A. bornensis* wood, which are randomly distributed all over the transverse surface of a stem, showed the typical features of compression wood. Anisotropic shrinkage was observed in the transverse directions of *A. bornensis* and *P. imbricatus* woods, which have no distinct growth rings. In the longitudinal direction, there was no definite correlation between the shrinkage and the specific gravity for normal wood, whereas the shrinkage for compression wood increased with increasing specific gravity. In the radial direction, the shrinkage of normal wood generally increased with increasing specific gravity, whereas no clear correlation was observed for compression wood. In the tangential direction, there was no correlation for either normal wood or compression wood. In the radial and tangential directions, no clear correlation was observed between shrinkage and Young's modulus for either normal wood or compression wood except for normal wood in the radial direction. On the other hand, there was a high correlation between shrinkage and the specific Young's modulus in the longitudinal direction for both normal and compression woods. This relationship was expressed by a hyperbolic equation.

Physical and mechanical properties required for violin bow materials, M. MATSUNAGA, M. SUGIYAMA, K. MINATO and M. NORIMOTO: *Holzforschung*, **50**(6), 511–517 (1996).

Pernambuco (*Guilandina echinata* syn *Caesalpinia echinata*), which has been used for the production of violin bows, was compared with alternative wood species from some physical and mechanical aspects and the reasons for why it is suitable for bows were discussed. A low value of loss tangent may be helpful for bow material, as the loss tangent of pernambuco was much lower than that of the other wood species. On the other hand, the most suitable Young's modulus could not be clarified, but the lower limit of Young's modulus needed for the bow must exist. Low loss tangent of pernambuco seems to be due to a high content of

extractives in the wood structure may have a different effect on the loss tangent. From the result that the wood with a higher extractive content showed a lower softening temperature, it can be concluded that the extractive in pernambuco is probably influential in the thermal bending of the bow. Redness of pernambuco has a correlation with loss tangent. Indentation hardness of pernambuco was somewhat higher at the same level of specific gravity than that of other wood species, but hardness would not be an inevitable property for the bow.

Temperature dependence of dynamic viscoelasticities of chemically treated woods, M. SUGIYAMA and M. NORIMOTO: *Mokuzai Gakkaishi*, **42**(11), 1049–1056 (1996) (in Japanese with English summary).

The temperature dependence of dynamic viscoelastic properties of five kinds of chemically treated woods as well as untreated wood was investigated. Three relaxations were detected in the untreated wood. They were attributed to the micro-Brownian motion of the cell wall polymers, the motion of adsorbed water molecules, and the motion of CH_2OH groups in the order of the decreasing temperatures at which they occurred. The formalization treatment restricted the micro-Brownian motion to some extent by the crosslinking of chains by OCH_2 bridges and induced the relaxation attributed to the motion of OCH_2 groups. Both the acetylation and propylene oxide treatments activated the micro-Brownian motion by the introduction of bulky groups and led to the relaxations due to the motions of the COCH_3 and OCH_2 groups, respectively. In the treatment with methylmethacrylate, relaxations attributed to the segmental motion of the main chain and the motion of the side chain of polymethyl methacrylate, in addition to the relaxations observed in the untreated wood, were detected. The impregnation of polyethylene glycol with an average molecular weight of 1,000 into the cell walls activated the micro-Brownian motion and restricted the segmental motion of polyethylene glycol molecules.

Fixation of compressive deformation of wood by heat treatment, W. DWIANTO, M. INOUE and M. NORIMOTO: *Mokuzai Gakkaishi*, **43**(4), 303–309 (1997) (in Japanese with English summary).

Cryptomeria japonica, *Pinus radiata* and *Paraserienthes falcata* wood specimens were compressed in the radial direction and subjected to a heat treatment. The effects of the heat treatment on the bending mechanical properties as well as the set recovery of the compressed samples were investigated. The heat treatment was done by three methods, beneath the surface of molten metal and in the presence and absence of air. Set recovery increased in the order of heating in the presence of air, beneath the surface of molten metal, in the absence of air when compared with the same heating temperature and time. However, it was expressed by a hyperbolic equation of weight loss, independent of the heating method and the wood species. Almost complete set fixation was achieved at about

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a 4.0% weight loss. On the other hand, the values of the moduli of elasticity and rupture were dependent on the heating method when compared at the same heating temperatures and times. However, they were expressed approximately by a linear equation of weight loss, regardless of heating method and wood species.

Carbon composites, charcoal as raw material for high-performance wood composites and their applications, S. ISHIHARA : *Polymeric Materials Encyclopedia*, Vol. 2/C. CRC Press, USA (1996).

A review is given a relationship between a rise in carbonization temperature and thermal conversion of wood and charcoal, and changes of performance properties of charcoal, carbon composites from wood charcoal as an electromagnetic shield and fire-resistant material, carbon-overlaid particleboard and new charcoal-based composites for environmental clean-up with 19th references.

Wood composites (High performance), S. ISHIHARA : *Polymeric Materials Encyclopedia*, Vol. 11/T-Z. CRC press, USA (1996).

Characteristic strength and physical properties wood as a material for building, manufacture or production of wood composites such as glue-laminated timber (Glulam), laminated veneer lumber (LVL), wood-based particle panel materials, plywood and fiberboard, and their mechanical and physical properties and their usages are reviewed with 1 reference.

Recent trend of advanced carbon materials from wood charcoals, S. ISHIHARA : *Mokuzai Gakkaishi*, **42**, 771–723 (1996) (in Japanese).

Thermal conversion of wood and biomass for production of advanced carbon materials with high-functions was described emphasizing on their carbonization process and new usage as environmental clean-up materials and electromagnetic-shielding ones.

Research and development of raw materials for functionally wood composites by thermochemical processing, S. ISHIHARA : *Wood Research and Technical Notes*, No. **32**, 23–29 (1996) (in Japanese).

A relationship between a rise in heat-treatment or carbonization temperature and changes of performance properties of wood or charcoal, development of raw materials for functionally wood composites by thermochemical processing, production of advanced carbon composites such an environmental clean-up materials and electromagnetic-shielding ones are reviewed with 29 references.

Research and development of carbon based materials for environmental clean-up from wood wastes by thermal conversion, S. ISHIHARA : *Resources Processing*, Vol. **44**, No. **1**, 35–38 (1997) (in Japanese).

A review is given wood biomass as a sustainable resource, a relationship between a rise in heat treatment or carbonization temperature and changes of performance properties of wood or charcoal, development of carbon-based materials environmental clean-up from wood wastes by thermal conversion with 17 references.

Removal of NO_x or its conversion into harmless gases by charcoals and composites of charcoals and metal oxides, S. ISHIHARA and T. FURUTSUKA : *Prep. Pap. Am. Chem. Soc., Div. Fuel Chem.*, **41**(1), 258–262 (1996).

NO_x emission from factories, automobiles and others have become worse, in particular, at urban areas. Removal of NO_x or its conversion into harmless gases such as N₂ should be described. Adsorption or catalytic reduction of NO over charcoals, effect of carbonization temperatures of charcoal on adsorption or conversion of NO_x or its conversion into harmless gases by charcoals and composites of charcoal and various kinds of transition metal oxides were also discussed.

Carbonized material adsorbents for the removal of mercury from aqueous solutions, S. ISHIHARA, L.L. PULIDO and T. KAJIMOTO : *Prep. Pap. Am. Chem. Soc., Div. Fuel Chem.*, **41**(1) 476–480 (1996).

Charcoal in itself is porous making it an excellent material for activated charcoal manufacture. However, few studies have been conducted in harnessing its potential for adsorption purposes especially in water treatment. This paper describes the possibility of utilizing charcoal materials from sugi (*Cryptomeria japonica*) for adsorbing heavy metals like mercury from aqueous solutions of different concentrations. The effect of soaking time, pore analyses and chemical properties on the adsorption capability of the carbonized materials were discussed. The pH value and chemical oxygen demand (COD) monitored during the soaking period were also described.

Development of the fire door with functional gradient wood I, H. GETTO and S. ISHIHARA : The 4th International Symp. Functionally Graded Material Proc., 92 (1996).

Inflammable materials like wood have been able to use for the fire door by the Ministry of Construction Notice No. 1125 in 1990. Wood has good fire endurance when it was made with a large phase. The door, however, has not been able to make such a large phase for building purpose.

It is difficult for the panel-stile constructed doors to satisfy the required ability as the fire door because panels of such doors are usually thin and it has been confirmed that the flame came out from panels insert portions. Therefore it is necessary to improve them.

It's well known that materials made of wood are treated with phosphorous and nitrogen compounds to improve fire endurance of them. Here two treatment methods were compared, which are heat-dry treatment and heat-press one.

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It was recognized that the latter method is more useful than the former method. The content of compounds in a heat-press treatment wood has decreased gradually from the surface to the core and the content of the surface becomes higher than it in a heat-dry treatment one.

In this system it was considered that gradient fire resistance with phosphorylation or esterification and polymerization of phosphorous and nitrogen compounds carried out on wood surface in existence of water.

To illustrate, 20 mm thick of heat-press treated Basswood (*Euphorbiaceae*, *Endospermum*) showed 1.5–2 times more in fire endurance by JIS A 1304 test method. In a solid timber, however, cracks sometimes occurs during fire test because of shrinkage by carbonization of wood and in this case, fire endurance decreases.

Then laminated boards which surface boards were treated by this way were used for panels of a wooden fire door and it has been authorized by the Ministry of Construction.

Removal of NO_x or its conversion into harmless gases through charcoals and composites of charcoals and metal oxides, Carbon Materials for The Environment, S. ISHIHARA, T. FURUTSUKA and L.L. PULIDO: *American Carbon Soc. Workshop.*, **74 (1996).**

In recent years, much attention has been devoted to environmental problems such as acid rain, photochemical smog, and water pollution. In particular, NO_x emissions from factories, automobiles, etc., in urban areas have become worse. To solve these problems, the use of activated charcoal to reduce air pollutants is increasing. Moreover, the capability of wood-based charcoal materials is not yet fully known. The removal of NO_x or its conversion into harmless gases such as N₂ should be described. In this study, the adsorption of NO_x or its conversion into harmless gases by charcoals or metal oxide-dispersed wood was investigated.

In particular, carbonized wood powder of sugi (*Cryptomeria japonica* D. Don) was used to study the effectiveness of using these materials in adsorbing or converting NO_x. Since wood charcoal is chemically stable, metal oxide with the ability of photocatalysis was dispersed into wood charcoal to improve its adsorption and capability to use the light energy effectively.

NO_x gas was passed through the reaction tube of wood charcoal or metal oxide dispersed wood charcoal. The concentration of NO_x gas was measured by a gas detector. During measurement, the reaction tube was lighted up or covered by black shield.

The adsorption or removal of NO_x over wood charcoal was better in the dark reaction than in the light reaction. Higher adsorption or removal is observed in all the carbonization temperatures in the dark reaction although the highest adsorption or removal is observed in 600°C.

On the other hand, the adsorption or removal of NO_x over the metal oxide dispersed

wood charcoal was better under exposure in light reactions than in dark ones.

Outdoor exposure tests of wood treated with glyoxal resins II. —Influences of mixtures of dipropylene glycol on deterioration of dimensional stability, T. ITOH and S. ISHIHARA : *Mokuzai Gakkaishi*, **42**, 668–676 (1996) (in Japanese with English summary).

To evaluate the influences of additions of dipropylene glycol (DPG) to glyoxal resin on weathering properties of resin-treated specimens, outdoor exposures under various conditions and artificial weathering tests, such as boiling and wetting-drying cyclic tests were made. Hinoki (*Chamaecyparis obtusa* Endl.) sapwood samples were impregnated with a series of mixtures in which the mixing ratios of glyoxal resin and DPG were different, followed by heating and condensation at a temperature of 150°C. The results obtained were as follows. In the outdoor exposure tests, weight losses (*W.L.*) and deterioration of dimensional stability were little, unless in adding excess DPG to the resin. In the boiling tests, pronounced *W.L.* and the deterioration of dimensional stability were found, especially in the specimens treated with glyoxal resin only (without DPG). By the addition of DPG to the resin, the deterioration in the boiling tests were reduced extremely. In the wetting-drying cyclic tests, the smallest *W.L.* occurred in specimens treated with resin only. Judging from these results, it proved that the deterioration of the specimens treated with glyoxal resin only were most influenced by the test conditions among all the resin-treated specimens. Comparing the three weathering tests, the results in the boiling tests were similar to those in the outdoor exposure tests, although the results of the wetting-drying cyclic tests were different from the results in the other weathering tests with respect to the relationships between reagent effluence and deterioration of dimensional stability.

Outdoor exposure tests of wood treated with glyoxal resins I. —Influence of reaction temperature on changes of dimensional stability, T. ITOH and S. ISHIHARA : *Mokuzai Gakkaishi*, **42**, 397–405 (1996) (in Japanese with English summary).

To evaluate weathering properties of wood treated with glyoxal resins, outdoor exposure tests and artificial accelerated tests, such as boiling or wetting and oven-drying cyclic tests, were made. Wood specimens were impregnated with a mixture of glyoxal resin and dipropylene glycol in the ratio of 50 : 50 (weight), followed by heated at 80–150°C, to accelerate the condensation. The information obtained was as follows :

(1) In the outdoor exposure tests, pronounced weight losses (*WL.*), especially, in the specimens that were treated at low temperatures, appeared in the early stage of exposure. With increases of *WL.*, bulking coefficients (*B*) and antiswelling efficiency (*ASE*) decreased, and moisture excluding efficiency (*MEE*) increased. The changes of their values diminished gradually with time.

(2) The occurrence of checks on the wood surface with exposure time, can be prevented by the addition of dimensional stability to wood.

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(3) The behaviors of deterioration in resin treated wood in the early stage of the boiling test were similar to those observed in the outdoor exposure. Judging from this result, it is considered that the outdoor exposure and boiling test are closely related to each other.

(4) Generally, the deterioration of dimensional stability in the specimens whose reaction temperatures were low were significant in the early stage of the wetting and oven-drying cyclic test that was used. On the other hand, the deterioration of the specimens where condensation had proceeded adequately were very little through ten cycles of wetting and oven-drying.

Compressive deformation of wood using hot rollpress and its fixation by glyoxal resin, T. ITOH and S. ISHIHARA: *Mokuzai Gakkaishi*, **43**, 52–60 (1997) (in Japanese with English summary).

Sugi (*Cryptomeria japonica* D. Don) sapwood specimens were compressed by a hot rollpress, and the fixation of the compressive deformations were attempted by using a mixture of glyoxal resin and dipropylene glycol in the ratio of 1:1 by weight. The deformations were fixed permanently when mixtures of more than 13.5% concentrations were impregnated previously into the specimens by a pressure processes and heated at 150°C for two hours after the compressive treatment. The fixation was considered to be attained by crosslinking, decrease of hygroscopicities, great hulking coefficients, and the dimensional stability resulting from them. As the specimens were dipped in the mixtures having more than 18.0% concentrations, almost no recovery of the deformation was recognized within five cycles of wetting and drying. Such restraint of recovery was considered to be because the surface layers, being impregnated with the resin delayed the penetration of water. Furthermore, to increase the net absorption of the resin, it was effective to compress the specimens by the rollpress as a pretreatment before dipping.

Improvement of fire retardancy of strandboards and plywoods by surface treatment of melamine with boric and phosphoric acids, W.Y. SU, SUBYAKTO, T. HATA, Y. IMAMURA and S. ISHIHARA: *Proc. of 3rd Pacific Rim Bio-Based Composites symposium Kyoto* 193–200 (1996).

An effective and simple method was developed to improve the fire resistance properties of wood-based materials by surface coating with melamine and fire retardants followed by subsequent hot pressing. The effectiveness of various formulations of fire retardants were investigated by two types of wood boards and two types of testing methods. Trimethylol melamine (fixation agent) was combined with phosphoric acid (TMP), boric acid (TMB), and dicyandiamide and phosphoric acid (TMDP), and dicyandiamide and boric acid (TMDB). All chemical formulations were found to improve the fire resistance of 12 mm-thick strandboards and 4 mm-thick plywoods. In strandboards, TMP treatment caused remarkable delay of ignition time when coated at 200 g/m². On the other hand, TMB was

more effective in preventing the samples from burning through at a relatively low coating level, i.e., 50 g/m². TMDP was effective in delaying the burning through, while TMDB improved the fire retardancy in the early stage of combustion. When the thin plywood was coated with TMP or TMB, there was a significant delay in ignition time. When TMP was applied, weight loss and charred length were evidently reduced. However, coating by TMB was found to have no significant influence on these fire resistance properties of weight loss and charred length.

Combustion behaviour of melamine-boric and -phosphoric acids treated wood using thermographic analysis, W.Y. SU, SUBYAKTO, T. HATA, Y. IMAMURA and S. ISHIHARA: *Proc. of the 1st International Wood Science Seminar Kyoto* 57–65 (1996).

A new way of non-contacting measurement called thermographic analysis method is introduced to estimate the fire endurance properties of the surface treated standboard. The effective and simple method which provides fire retardant properties for wood-based materials was developed by surface coating followed by hot pressing of melamine containing fire retardants. The fire retardants used were mixtures of trimethylol melamine and phosphoric acid (TMP) or boric acid (TMB), and trimethylol melamine, dicyandiamide and phosphoric acid (TMDP) or boric acid (TMDB). All chemical formulations improved the fire retardancy of standboard. Heat distribution and fire endurance of these materials could visually and correctly be investigated from thermographic analysis.

Improvement of the fire retardancy of strandboards by surface treatment with melamine and boric or phosphoric acids, W.Y. SU, SUBYAKTO, T. HATA, Y. IMAMURA and S. ISHIHARA, *Mokuzai Gakkashi*, **43**, 75–81 (1997).

An effective and simple method of providing fire retardant properties to wood-based materials was developed by the surface coating and subsequent hot pressing of melamine containing fire retardants. The fire retardants were mixtures of trimethylol melamine and phosphoric acid (TMP) or boric acid (TMB), and those of trimethylol melamine, dicyandiamide and phosphoric acid (TMDP) or boric acid (TMDB). All chemical formulations improved the fire retardant performance of strandboards. Both TMB and TMP treatments caused remarkable delays of ignition times when coated at 200 g/m²; however, TMB was more efficient in protecting samples from burning through at the lowest level of treatment. The addition of dicyandiamide was effective in delaying the burning through time for phosphoric acid; however, it improved the fire retardancy in the early stage of combustion for boric acid. The TMB and TMDB treated strandboards formed uniform charred layers on the surfaces, and the homogeneity of the charred layers contributed to homogenous heat distribution resulting in better fire retardant properties. Much information on heat distribution and fire retardancy during the testing was obtained from a thermographic analysis.

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Combustible behaviour of boron-alkali metal treated wood by using thermographic analysis, W.Y. SU, T. HATA, Y. IMAMURA and S. ISHIHARA : *Mokuzai Gakkaishi*, **43**, 82–89 (1997).

Douglas fir veneer and filter paper were treated with the mixtures of boric acid and alkali metals at the molar ratios of 1 : 0.5, 1 : 1, and 1 : 2, and exposed to the standard flammability test. Compact thermographic apparatus was used to record the temperature distribution and changes. The boron-lithium treated samples resulted in a shorter char length than boron-sodium or -potassium treated ones. The shortest char length was obtained from the samples treated with 1 : 0.5 molar ratio of boron to lithium. The lower the atomic number of the alkali metal, the shorter the char length was observed. The boron-lithium chemical treatment was the most effective one which protected the samples to be heated compared with boron-sodium and boron-potassium treatments. Charring and combustible behaviour could be clearly observed from the thermographic images.

Enhancement of weathering properties of wood by phenolic-resin impregnation coupled with laser incision, Y. IMAMURA, M. KASHIHARA, K. ANDO, N. HATTORI and S. KITAYAMA : *Proc. of IUFRO working party on Surface and Finishing of Wood*, 1–7 (1996).

To enhance the weathering properties of wood, the surface portions of the specimens were thoroughly incised using 1.7 kW CO₂ laser, and impregnated with low-molecular weight phenolic-resin. The specimens which were compressed while heating to cure the resin were exposed to out-door weathering to evaluate the high performance properties. The surface portion which were incised and impregnated with the resin were selectively compressed providing the hardened surfaces. Degradation of the wood surfaces by UV light irradiation and rain fall was evidently suppressed for the treated specimens.

Control of termite attack using a trapping method and acoustic emission (AE) monitoring a case study at an electric power plant, Y. FUJII, Y. IMAMURA, E. IWATSUBO and S. YAMAMOTO : *Proc. of Inf. Res. Group on Wood Preserv. IRG/WP*, 97–10224 (1997).

To prevent subterranean termites (*Coptotermes formosanus* Shiraki and *Reticulitermes speratus* Kolbe) from invading the buildings of an electric power plant and to control their attack, artificial traps were buried around the buildings. The attack of the termites in and around the traps was monitored by detecting acoustic emissions (AE) generated by the feeding behavior of the workers. The cylindrical artificial traps were 600 mm long and 300 mm in diameter, and consisted of pieces of Japanese red pine surrounded by slender polystyrene foam sticks. Termite inhabitation was observed in eight of the ten traps set, and particularly high levels were found in three traps. The traps were renewed every one or two months. The amount of termites inhabiting the traps decreased drastically after the first renewal, but varied only slightly over the following two and a half years. The amount of termites in the traps increased when the traps were not renewed. Termite activity was

significantly restricted by installing artificial traps and no additional serious attacks were found in or around the buildings during the study period. AEs generated by feeding activities were monitored by piezoelectric AE sensors attached to the wooden sticks in the traps or to wooden bait stakes near the trap. The rate of AE events varied according to feeding activity which was associated with the number of termites in the trap and the temperature.

Relationship between the type of feeding behavior of termites and the acoustic emission (AE) generation, H. MATSUOKA, Y. FUJII, S. OKUMURA, Y. IMAMURA and T. YOSHIMURA: *Wood Research*, No. **83**, 1-7 (1996).

Three pest termite species, *Coptotermes formosanus* Shiraki, *Reticulitermes speratus* (Kolbe) and *Cryptotermes domesticus* Haviland were used to investigate the relationship between the types of feeding behavior and the generation of acoustic emission (AE) using a charge coupled device (CCD) camera under AE monitoring. Three types of feeding behavior, "pulling", "cutting" and "scraping", basically using the mandible and the maxillae, were observed with the CCD camera. When pulling behavior was observed, AEs of larger amplitude were interruptedly detected. Frequent AEs of tower amplitude were detected when cutting and scraping were observed.

Dimensional stabilization of waterlogged wood—The effect of PEG, sugar and sugar alcohol on dimensional stabilization, A.K. KANG, Y. IMAMURA and S.J. PARK: *Archeological and Natural Science*, **33**, 39-56 (1996) (in Japanese with English summary).

Dimensional stabilization of waterlogged oak wood (*Quercus acutissima*) treated with various chemicals of PEG, sugar and sugar alcohol was examined to evaluate the proper treatment period and initial concentrations of the chemicals. All wood samples ($2(R) \times 2(T) \times 2(L)$ cm) were cut from one part of the waterlogged wood, and impregnated with PEG #4000, sucrose, glucose, lactose, mannitol+PEG #4000, mannitol+sucrose, lactitol, xylitol and maltitol. The concentrations of the impregnation solutions started at 10%, and were raised up to 30%, 50%, 70%, 80% and 90% after 3 days each under the temperature condition at 60 to 65°C. The samples were air-dried to measure the dimensional changes.

In all treatments, when the concentrations of chemicals reached 30%, the weight of samples increased considerably, however, the weight stopped increasing or increased very slightly when the solutions of 70% or above concentrations were applied. Different effects between the chemicals were found on the shrinkage of the treated samples after drying at room temperature. The shrinkage in the cross-sections of samples treated with PEG #4000, sucrose, lactose, mannitol+PEG #4000 and mannitol+sucrose decreases, as the concentrations increased, and high dimensional stability were obtained for the samples treated in the concentrations above 80%. For the samples treated with glucose and sugar alcohol (lactitol, xylitol, maltitol), swelling and cracks were observed possibly because the

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chemicals moved from the center of the sample to the surfaces. From these results, high dimensional stabilization was found in samples treated with sucrose, mannitol + PEG #4000 and mannitol + sucrose up to 70% concentration.

When the initial concentration was changed, very interesting results were found. For the samples treated with PEG #4000, the weight decreased and shrinkage took place, when the initial concentration was adjusted at 70 or 80%. On the other hand, for the samples treated with sucrose, the weight of the samples increased and no shrinkage took place, even though the solutions of the initial concentration at 50, 70 or 80% was introduced. These results suggested that sucrose could be used in the high initial concentration however, PEG #4000 should be used in the low one and then gradually increased to the higher concentrations to get good impregnation.

Evaluation of weathering resistance of the commercial pigmented stains by outdoor exposure test in Japan, M. KIGUCHI, Y. KATAOKA, S. DOI, M. MORI, M. HASEGAWA, S. MORITA, M. KINJO, Y. KADEGARU and Y. IMAMURA: *Wood Preservation*, **22**, 150–158 (1996) (in Japanese with English summary).

The weathering resistance of twelve commercial pigmented stains on Douglas-fir plywood and glulam (glue laminated timber) was evaluated by exposing coated specimens at six test sites (Hokkaido, Tsukuba, Toyama, Kyoto, Kagoshima, and Okinawa) in Japan. The stains which were of two types, penetration and film forming, differed in their mode of failure during exposure. The penetration type failed through the development of cracks in the wood surface whereas the film forming type failed via film failure. Deterioration of coated wood surfaces was evaluated by calculation on a defected area using transparent squared sheet and a water repellency test. In the case of the film forming stains the development of even a small defect in the film affected the appearance of the treated wood surface. Kagoshima was the most severe site for the exposure tests whereas Hokkaido was the least severe one. However, differences between the exposure sites were not great. Glue line failure occurred in more than 70% of the glulam specimens after 3.5 years exposure and the maximum depth of delamination was approximately 7 mm.

Liquid penetration of precompressed wood V. —Effects of cyclic loading, type of impregnated chemicals and annual ring angles on the uptake of water or oily solvents, I. IIDA, S. MORI, Y. NAKAMURA, H. SAKAI and Y. IMAMURA: *Mokuzai Gakkaishi*, **42**, 581–588 (1996) (in Japanese with English summary).

For the development of pre-compression treatments to accelerate liquid penetration into refractory wood, the effects of cyclic loading, the types of the liquids and the annual-ring angles of the specimens on the liquid uptakes were evaluated.

When three-cycle loading with a constant strain up to 50% was applied to wood specimens, the stresses of the second and third cycles remarkably decreased to less than that

of the first one. In the case of three-cycle loading with rising strains up to 30, 40 and 50%, the stresses of the second and third cycles increased exceeding over the prior one. Improvement of liquid penetration virtually was recognized after the pre-compressed woods were impregnated with water-born preservatives under pressure. The largest retention of liquid was detected for wood specimens which had been treated under three-cycle loading at constant strains up to 50%. No significant difference of liquid retention was detected among the three types were water-born preservatives of CCA, copper naphthenate and zinc versanate. Pre-compressed wood also took up a considerable amount of hydrophobic oil-based solution when the fixed strain was released in the liquid. In this case, the liquid uptake was affected largely by the moisture contents of the specimens when compressed, and the amounts decreased at more than 25%. The visible damages hardly were detected for the specimens with annual ring angles smaller than 45 degrees, however, the amount of liquid uptake gradually decreased with increases of annual ring angles. This was suggested to be caused by the reduction of liquid pass-ways and the incomplete recoveries of compression strains, which originated from the decreases of cell-wall fractures around pits and the occurrences of separations along the middle layer, respectively.

Research and development of carbon composites from wood charcoal for environmental clean-up and their applications, L.L. PULIDO, S. ISHIHARA, Y. IMAMURA and T. HATA: *Wood Research*, No. **83**, 43–46 (1996).

This study was conducted to investigate the possibility of using carbonized wood materials from sugi (*Cryptomeria japonica* D. Don) as adsorbent materials in single and mixture aqueous solutions of some of the toxic materials such as heavy metals.

Microstructural investigation of carbon fibre reinforcement in a silicone nitride matrix, T. HATA, P.M. BRONSVELD, J.T.M.D. HOSSON, J.B. VEYRET and E. BULLOCK: Proceedings of 11th European Congress on Microscopy (EUREM '96) (1996).

The purpose of this study was to find the reason for the debonding within the carbon fibrils at the rupture of the composites and to discuss the role of the coating on the mechanical properties of the composites. The reason for the debonding within the fibres was given by TEM, HREM and SEM images and the role of the coating on the mechanical properties of the ceramic matrix composites was also discussed.

The fibrils are oriented parallel to the fibre axis. No fold texture on the fibre surface is seen, which is assured by the higher modulus of 500 GPa. By indexing the diffraction pattern, the (002) plane spacing was found to be 0.343 nm. It is typical for the turbostratic graphite with building blocks of approximately 5 nm in size showing up as separate crystallites.

It is concluded that the existence of those fibrils easily cause debonding within the fibers during the process of cooling down or in mechanical testing. Designing the interface

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between fiber and matrix by balancing the strength of the interface with that between the fibrils will lead to higher strength of the composites.

Novel wood science and study in Europe (from the experience for 10 months in abroad), T. HATA: *Wood Industry*, **51**(10), 465–469 (1996) (in Japanese).

The newest information on the development and research in the fields of wood composites in Europe and Canada was introduced from the authors' experience.

Mass loss observation of bamboo-particleboard and oriented strandboard fire retardant using cone calorimeter, SUBYAKTO, W.-H. SU and S. ISHIHARA: First International Wood Science Seminar Proceedings, 66–73 (1996).

Research on enhancement of fire endurance of building materials such as wood and wood composite should be pursued to produce fire resistive products. This experiment was aimed at observing effect of addition of fire retardants based on amino resin on the properties of bamboo particleboard and oriented strand board (OSB), trimethylolmelamine and phosphoric acid (TP), and mixed of trimethylolmelamine, dicyandiamide and phosphoric acid (TDP). Chemicals were coated on one surface of the board and varied at the amount of 50, 100 and 200 g/m², then hot pressed at the temperature of 160°C for 5 minutes with a pressure of 5 kgf/cm². All boards were tested on their fire properties using a cone calorimeter in accordance with ISO 5660. Samples were tested horizontally with heat flux set at 40 kW/m².

Results shown that boards have better fire properties compared to untreated boards, ignition time was longer and the mass loss was smaller. At the beginning of the test mass loss rate of treated boards were lower than untreated boards which indicates the effectiveness of coating method. Bamboo particleboard coated with TDP gave better result than TP, on the contrary OSB coated was better than TDP. Overall the OSB coated with TP at 200 g/m² showed the best fire endurance.

Fire endurance of surface densified wood treated with fire retardant, T. KAJIMOTO, T. HATA and S. ISHIHARA: First International Wood Science Seminar Proceedings, 201–208 (1996).

New and economical type of fire retardant treatment was applied to the solid woods of sugi (*Cryptomeria japonica* D. Don) and albizzia falcata (*Albizzia falcata* Backer). The chemicals used were trimethylolmelamine mixed with phosphoric acid. The sample surfaces were coated with these chemicals and were preheated followed by hot pressing. The samples were evaluated by bending test, creep under fire test and standard fire test. Results showed that the fire endurance of surface densified sugi or albizzia falcata was improved, compared to that of the untreated ones. Coating a larger amount of the chemicals or the pre-heating process greatly improved the fire retardance of the wood. The

optimum condition in this experiment was achieved by balancing the densifying ratio, pressing temperature and pressing time.

Future of study on fire retardancy of wood, T. HATA : *Wood Industry*, **51**(3), 166–168 (1997) (in Japanese).

The philosophy of the study on fire retardancy of wood was plainly shown.

Pyrolysis of wood, T. HATA : Wood preservation, Wood science seminar 12, Kaiseisha Ltd., 155–160 (1997) (in Japanese).

Pyrolysis, ignition and burning, fire retardant performance of glue-lam with larger cross section and the functions as carbon materials of wood were plainly explained for university students.

Fire retardants and fire retardant treatment, T. HATA : Wood preservation, Wood science seminar 12, Kaiseisha Ltd., 161–164 (1997) (in Japanese).

Fire retardancy of wood, fire retardants, fire retardant treatment and the methods for standard fire test were shown for university students.

Colony elimination of *Reticulitermes speratus* (Kolbe) (Isoptera: Rhinotermitidae) by bait system, K. TSUNODA, H. MATSUOKA, T. YOSHIMURA and K. YAMAUCHI : *The Int. Res. Group on Wood Preserv.*, Document No. IRG/WP 97–10189, pp. 3 (1997).

Following a two-year estimation of the foraging population and territory of *Reticulitermes speratus* (Kolbe) by triple-mark-recapture program at Uji campus of Kyoto University, bait stations (commercial products containig hexaflumuron) were set up in the foraging territory in October 1995 to eliminate the colony. Inspections demonstrated that the number of test stakes with foraging termites decreased after May 1996. No attack was finally observed in July 1996. As a later inspection in October 1996 reconfirmed no termite hits on any wooden stake in the foraging territory, the colony was considered to be eliminated by baits.

Trends in research and development of wood preservatives, K. TSUNODA : *Mokuzai Kogyo (Wood Industry)*, **52**(5), 232–236 (1997) (in Japanese).

Recent research and development of wood preservatives is reviewed through the citation of papers over the last 15 years. Although a few wood preservatives have been commercialized as alternatives to CCA, performance of the treated materials should be examined under various conditions by considering international standardization of hazard classes.

Biological attacks on marine timbers, K. TSUNODA : in “Wood Science Series 12, Preservation and Durability” (eds., S. Yaga, S. Kawauchi and Y. Imamura), Kaiseisya, 104–107 (1997).

ABSTRACTS

Biological attacks on timbers used in marine are reviewed with a brief description of each agent.

Degradation of wood in the digestive tract of a higher termite, *Nasutitermes takasagoensis* (Shiraki) (Isoptera : Termitidae), T. YOSHIMURA, K. TSUNODA and M. TAKAHASHI: *Mokuzai Gakkaishi*, **42**(12), 1250–1257 (1996).

A wood-feeding higher termite, *Nasutitermes takasagoensis* (Shiraki) was employed for observing the biodegradation of wood fragments in the digestive tract using a scanning electron microscope. The contents of the foregut were wood fragments of two sizes, 10–30 μm and 100–300 μm , similar in to the morphological characteristics of fed wood meal. Wood fragments in the first part of the hindgut just anterior to the enteric valve varied in size consecutively from less than 10 μm to 300 μm , indicating severe enzymatic degradation. The hindgut posterior to the enteric valve was swollen and the contents of the posterior part consisted of a small amount of wood fragments of the size of 50–300 μm , and the many smaller (less than 10 μm) and random-shaped particles which appeared to be digestive residues. These observations suggest the following wood degradation mechanism by *N. takasagoensis*: 1) Degradation and the following down-sizing of ingested wood fragments by the termite's enzymes in the midgut and the hindgut anterior to the enteric valve, 2) Final decomposition of down-sized fragments in the hindgut posterior to the enteric valve.

Studies on the parasitic organisms of termite, *Coptotermes formosanus* Shiraki, T. YOSHIMURA: *Jpn. J. Environ. Entomol. Zool.*, **8**(1), 48–59 (1996) (in Japanese with English summary).

Recent researches of the author on the following two subjects are reviewed.

1) Pathogenicity of a entomogenous fungi, *Conidiobolus coronatus* Tyrrell and MacLeod, to *Coptotermes formosanus* Shiraki.

2) Contribution of the protozoan fauna to nutritional physiology of *C. formosanus* Shiraki.

Wood degradation by termites—In cases of *C. formosanus* and *N. takasagoensis*—, T. YOSHIMURA: *Shiroari (Termite)*, No. **107**, 3–11 (1997) (in Japanese).

Two wood-feeding termites, *Coptotermes formosanus* Shiraki (lower termite) and *Nasutitermes takasagoensis* (Shiraki) (higher termite) were employed, and their wood degradation mechanism was discussed.

From the observations of the gut contents of these termites, wood degradation mechanism were suggested as follows:

1) *N. takasagoensis*: a) Degradation and the following down-sizing of ingested wood fragments by the termite's enzymes in the midgut and the hindgut anterior to the enteric valve, b) Final decomposition of down-sized fragments in the hindgut posterior to the enteric

valve.

2) *C. formosanus* : a) Partial degradation of ingested wood fragments, characteristically in the non-crystalline region of cellulose, by termite's enzymes in the midgut, b) Final decomposition of the partially degraded fragments in the bodies of the two larger-sized protozoan species in the hindgut.

Termites, T. YOSHIMURA : in "Wood Science Series 12, Preservation and Durability" (eds., S. Yaga, S. Kawauchi and Y. Imamura), Kaiseisya, 95–103 (1997).

Ecology, physiology, and environmental impacts of termites are reviewed with a detailed description of Japanese economically important species.

Degradation of termiticides and its effect on performance against Thailand's economically most important subterranean termite, *Coptotermes gestroi* Wasmann (Isoptera : Rhinotermitidae). I. Soil burial, Y. SORNNUWAT, C. VONGKALUANG, T. YOSHIMURA, K. TSUNODA and M. TAKAHASHI : *Mater. Organismen*, **30**(2), 133–142 (1996).

Effect of soil burial on recovery rates and termiticidal effectiveness of three synthetic pyrethroids (cypermethrin, fenvalerate and permethrin), the silane (silafuofen) and an organophosphate (chlorpyrifos) when treated wood blocks were buried in soil was investigated. All the chemicals degraded with time, and the loss of effectiveness was especially evident for blocks treated at lower concentrations. Chlorpyrifos degraded more rapidly than the other termiticides in test, and the recovery rates decreased less than 10% after 3 months even at the highest concentration. Silafuofen showed the highest resistance to soil burial, followed by the three synthetic pyrethroids. Results of bioassays using the most economically important subterranean termite in Thailand, *Coptotermes gestroi* Wasmann, agreed favourably with the results of recovery rates of termiticides, and showed the possibility of using all test chemicals as alternatives termiticides in the country.

Degradation of termiticides and its effect on performance against Thailand's economically most important subterranean termite, *Coptotermes gestroi* Wasmann (Isoptera : Rhinotermitidae). II. Indoor and outdoor exposure in above ground situation, Y. SORNNUWAT, C. VONGKALUANG, T. YOSHIMURA, K. TSUNODA and M. TAKAHASHI : *Mater. Organismen*, **30**(2), 143–154 (1996).

Experiments were conducted to evaluate the chemical degradation and the change of termiticidal performance of three synthetic pyrethroids (cypermethrin, fenvalerate and permethrin), the silane (silafuofen) and an organophosphate (chlorpyrifos) treated wood blocks after certain periods of indoor and outdoor exposure in above ground situation. From the mass losses of untreated wood blocks, the outdoor weathering seemed to be more severe than the indoor weathering. Natural weathering consisting of ultraviolet irradiation and other unspecified variables exerted less effects on the recovery rates and the termiticidal

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effectiveness of all chemicals than when buried in soil. All chemicals at every concentration provided good termiticidal performance (less than 3% wood consumption of treated blocks) even after 24 months' indoor weathering, but only 6 months' for outdoor weathering. Chlorpyrifos degraded more rapidly than the other termiticides in both indoor and outdoor weathering. Among the synthetic pyrethroids, cypermethrin showed the highest resistance to natural weathering, providing termiticidal performance even at the lowest concentration up to 12 months' exposure, followed by permethrin and fenvalerate. Silafluofen seemed to be the most susceptible to outdoor exposure among termiticides other than chlorpyrifos, and lost its effectiveness in every concentration within 12 months. Although the results of bioassay suggest the possibility of these chemicals as alternative termiticides against the economically most important subterranean termite, *Coptotermes gestroi* Wasmann in Thailand, the higher concentrations are recommended for long-term protection in outdoor above ground situation.

Foraging populations of *Coptotermes gestroi* (Isoptera : Rhinotermitidae) in an urban area, Y. SORNNUWAT, K. TSUNODA, T. YOSHIMURA, M. TAKAHASHI and C. VONGKALUANG : *J. Econ. Entomol.*, **89**(6), 1485–1490 (1996).

Three field colonies of the Thai subterranean termite *Coptotermes gestroi* Wasmann in an urban area of Bangkok, Thailand, were selected to estimate the foraging populations, using the triple mark-recapture procedure. The foraging populations ranged from 1.13 to 2.75×10^6 per colony. Intraspecific variation in foraging populations among the colonies might be caused by the age of colonies, environment conditions, and seasons.

Relationship between the type of feeding behavior of termites and the acoustic emission (AE) generation, H. MATSUOKA, Y. FUJII, S. OKUMURA, Y. IMAMURA and T. YOSHIMURA : *Wood Res.*, No. **83**, 1–7 (1996).

Three pest termite species, *Coptotermes formosanus* Shiraki, *Reticulitermes speratus* (Kolbe) and *Cryptotermes domesticus* Haviland were used to investigate the relationship between the types of feeding behavior and the generation of acoustic emission (AE) using a charge coupled device (CCD) camera under AE monitoring. Three types of feeding behavior, “pulling”, “cutting” and “scraping”, basically using the mandible and the maxillae, were observed with the CCD camera. When pulling behavior was observed, AEs of larger amplitude were interruptedly detected. Frequent AEs of lower amplitude were detected when cutting and scraping were observed.

Lignin modification by termite and its symbiotic protozoa, K. KYOU, T. WATANABE, T. YOSHIMURA and M. TAKAHASHI : *Wood Res.*, No. **83**, 50–54 (1996).

Lignin ingestion and degradation by *Coptotermes formosanus* Shiraki and its symbiotic protozoa were investigated by microscopic observations and chemical analyses. Workers of

C. formosanus fed on Milled-Wood-Lignin (MWL) prepared from the wood meal of akamatsu (*Pinus densiflora* Sieb. et Zucc.) showed the lower survival rate comparable to that of starvation control, indicating that MWL was not utilized by termites as nutrient. But survival rate of workers fed on wood meal was higher than that of holocellulose-fed workers, lignin in wood may have a role to support the health condition of termites. Middle-sized protozoa, *Holomastigotoides hartmanni* Koidzumi, actively ingested MWL but not the large-sized protozoa, *Pseudotriconympha grassii* Koidzumi, and the small-sized species, *Spirotrichonympha leidy* Koidzumi. Although MWL particles in the body of *H. hartmanni* showed irregular surfaces might indicate the enzymatic degradation, chemical analyses of fecal lignin did not show any major change of lignin molecular itself. However, fecal lignin was found to be composed of lower molecular weight fractions than MWL, a modification of Lignin-Carbohydrate-Complex (LCC) was suggested.

Effect of vapor phase formalization of boric acid treated wood on boron leachability and biological resistance, M.K. YALINKILIC, S. YUSUF, T. YOSHIMURA, M. TAKAHASHI and K. TSUNODA: *Proceedings from the Third Pacific Rim Bio-Based Composites Symposium*, December 2-5, 1996, Kyoto, 544-551 (1996).

Outdoor use of boron treated wood urges boron be fixed in wood for a reasonably long period of service. As one of the possible techniques of boron fixation through blocking reaction sites of wood (OH-group) by crosslinks of formaldehyde in order to reduce water attractiveness of wood, vapor phase formalization was employed with sugi wood pretreated with boric acid at various concentrations. Test specimens were then subjected to leachability and biological tests in order to reveal boron leachability and biological performance of boron-formaldehyde treatment system. Ion chromatography was used for boron detection from leachates.

Results showed that boron-formaldehyde treatment was to some extent better than the sole boron treatments in performance, after being leached by running water. Vapor phase formalization slowed down boron leaching from wood, but could not keep boron from leaching as remarkable as expected. High boron content in wood reduced formaldehyde weight gain. Decay resistance of boron-formaldehyde treated wood was found excellent against *Coriolus versicolor* and *Tyromyces palustris*, while termite resistance was slightly improved.

Oxygen index levels and thermal analysis of wood treated with melamine formaldehyde-boron combinations, M.K. YALINKILIC, W.-Y. SU, Z. DEMIRCI, E. BAYSAL, M. TAKAHASHI and S. ISHIHARA: *The Int. Res. Group on Wood Preserv.*, Document No. IRG/WP/97-30135 (1997).

Melamine formaldehyde (MF) resin was impregnated into Scots pine (*Pinus sylvestris* L.) specimens with aqueous solutions of 5, 10, 20 and 34% concs. Then, boric acid (BA) and

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borax (BX) was added to MF resin exclusively or together at the concentration levels of 0.25, 1.00 and 4.70% to each level of resin concs. given above. BA and BX mixtures were prepared at the 5:1 (W/W) ratio considering resultant pH of solutions and better fire resistance which was studied earlier. Untreated and treated wood with all combinations were subjected to oxygen index test according to ASTM D 2863-91 and thermal analysis. Results were evaluated in terms of improvement of fire retardant performances of wood by sole or combination treatments.

Incorporation of phenyl boronic acid treatment with vapor phase formalization, M.K. YALINKILIC, S. YUSUF, T. YOSHIMURA, W.-Y. SU, K. TSUNODA and M. TALKAHASHI: *The Int. Res. Group on Wood Preserv.*, Document No. IRG/WP/97-40083 (1997).

Phenyl boronic acid (PBA) treatment was incorporated with vapor phase formalization (VPF) in order to increase dimensional stability and boron fixation in wood as well as enhancement of biological resistance. Five and ten hours of VPF were applied after PBA treatment as 0.34, 0.50, 1.00 and 2.00% concs. of aqueous solutions. Antiswelling efficiency (ASE) attended to 71% in specimens impregnated with 0.50% PBA solution prior to five hour VPF. Leachability test results were supportive to presume a possible chemical bonding of PBA and formaldehyde. Decay test results indicated that formalization impacts superior properties to PBA treated wood against test fungi *Tyromyces palustris* and *Coriolus versicolor*, each as brown- and white-rot fungus, respectively. Fungal attack was completely inhibited with five hours of VPF and PBA treatment at the lowest loading level in the study. Shorter formalization seems also to achieve the required fungicidal effectiveness with a little amount of PBA retention. Weight loss caused by Formosan termite (*Coptotermes formosanus* Shiraki) could be lowered by PBA-VPF treatments in addition to considerable increase in termite mortality.

Do heat treatment accelerate the biodegradation of wood materials? S. DOI, Y. KURIMOTO, M. TAKAHASHI and T. YOSHIMURA: *Proceedings from the Third Pacific Rim Bio-Based Composites Symposium*, December 2-5, 1996, Kyoto, 159-165 (1996).

In order to investigate the effects of heating on biodegradation of wood materials, steamed or dry-heated heartwood samples of several species were exposed to termites or decay fungi. Heat-treated samples showed large weight losses due to termite attack compared to control samples without heat treatments. Japanese larch and Japanese beech were heavily affected by steaming. No definite effect of steaming was observed on wood decay. Attractive effects of steaming at atmospheric pressure of wood materials on termites should be investigated together with the effects of dry-heating on wood decay.

Effects of steaming heat treatment of wood on the stimulation of termite feeding, S. DOI, Y. KURIMOTO, M. TAKAHASHI and T. YOSHIMURA: *The Int. Res. Group on Wood Preserv.*,

Document No. IRG/WP/97-10189 (1997).

We have already reported that steamed Japanese larch heartwood samples were suffered a serious attack by subterranean termite, *Coptotermes formosanus* both in choice and no-choice feeding tests. This is possibly caused by the yield of termites stimulants in the wood samples resulting from the steaming process. Since the steaming heat treatment has often been applied to other several timber species for their drying, dimensional stabilization, etc., attention should be paid to them on the stimulant effect of this treatment on termite attack. This paper deals with the results of choice and no-choice feeding tests of termites using steamed or dry-heated samples of wood for commercial use in Japan. Some steamed wood species were heavily attacked by *C. formosanus* or *Reticulitermes speratus* while all dry-heated samples were not attacked more than unheated controls.

Characteristics of the pigments produced by sap-staining fungi, M. MORI and M. TAKAHASHI: *The Int. Res. Group on Wood Preserv.*, Document No. IRG/WP/97-10023 (1997).

The present study was conducted to characterize the pigments produced by sap-staining fungi, *Aureobasidium pullulans* (de Bary) Arnaud and *Ceratocystis piceae* (Münch) H. and P. Sydow. The pigments isolated from tested fungi were identified as melanins by spectroscopic methods (UV and infrared spectra). The UV and the infrared spectra of the fungal pigments were similar to those of the synthetic melanin. The spectra also indicated the similar structure of both fungal melanins. The adsorption bands at aliphatic CH in infrared spectra were stronger in fungal melanins than in synthetic melanin. From elemental analyses, H/C ratio of fungal melanins were higher than that of synthetic melanin. These results suggested that both fungal melanins had a high amount of aliphatic structures.

Biological durability of cement-bonded particle board, Q. WANG and M. TAKAHASHI: *The Int. Res. Group on Wood Preserv.*, Document No. IRG/WP/97-20115 (1997).

Cement-bonded particleboard (CBP) is a panel product manufactured from a combination of wood particle and cement with various ratio. The wood particle is used as a reinforced material and the cement as an inorganic binder. As its many excellent properties, such as high weathering resistance, sound attenuation, good acceptance of a wide range treatment, etc., CBP is widely used as a facade material in Japan. The present study is carried out to investigate the biological durability of CBP. The material involved in the study was a standard commercial product and obtained directly from one Japanese producing company. Two experiments were conducted. One was decaying test used as a Japanese standard. The other one studied the rotting fungi's effect on the internal bonding strength of the material. The test results were also compared with other structural wood-based composites.

Curing behavior of wood adhesives under high steam pressure, K. UMEMURA, S. KAWAI, H. SASAKI, R. HAMADA and Y. MIZUNO: *J. Adhesion*, **59**, 87-100 (1996).

ABSTRACTS

Steam-injection pressing is a recent development for manufacturing wood products. The curing mechanism and behavior of wood adhesives during steam-injection heating and hot-platen heating may cause differences in both chemical and physical aspects. The curing of wood adhesives under high steam pressure using an especially designed reaction cell is discussed. The adhesives used in this study were phenol-formaldehyde (PF), urea-formaldehyde (UF), melamine-formaldehyde (MF), and isocyanate (IC) resins. At different curing times, the heating temperature (steam pressure) applied to cure the adhesives was 160°C (6 kgf/cm²). Results were examined by analytical methods using FR-IR, ¹³C-NMR, dynamic mechanical analysis and solvent extraction. (1) By steam-injection heating, PF resin immediately cured to some degree in a few minutes and maintained an equilibrium situation. In this case, the reaction was accompanied by the disappearance of the ether structure. (2) In UF resin, results from IR data clarified different reactions between hot-platen heating and steam-injection heating. During steam-injection heating, as heating time increased, UF resin returned to its liquid state under the influence of hydrolysis. (3) MF resin was almost cured under steam-injection in a short heating time compared with hot-platen heating. (4) IC resin foamed and cured in a short heating time under steam-injection. It was proved that steam-injection heating was more effective than by hot-platen heating for IC resin.

Factors affecting isocyanate-inorganic bonded board properties by steam injection pressing, D.A. EUSEBIO, S. KAWAI and H. SASAKI: *FPRDI Journal*, **22**(1), 55–67 (1996).

Isocyanate-cement bonded particleboards with a target density of 1.2 g/cm³ were produced with the introduction of steam injection pressing (SIP) at a steam injection time (SIP) and steam pressure of 3 sec and 1.25 kgf/cm², respectively. The effect of varying the wood : cement, (Wo : Ce) ratio at 3, 5, 10 and 15 min of total pressing time and isocyanate (IC) resin content on the properties of the boards determined. Results revealed that with the incorporation of IC resin and introduction of SIP, cement-bonded particleboard could be handled immediately after a few minutes of pressing. The relationship between Wo : Ce ratio and TPT showed that both mechanical and physical properties were governed more by varying the Wo : Ce ratio rather than TPT. On the other hand, the effects of increasing the IC resin content varied depending on the Wo : Ce ratio. The most favorable outcome was obtained at 6% IC resin at a Wo : Ce ratio of 1 : 1.

Rapid curing of cement-bonded particleboard II. Curing mechanism of cement with sodium hydrogen carbonate during steam injection pressing, W. NAGADOMI, Y. KUROKI, D. A. EUSEBIO, L. MA, S. KAWAI and H. SASAKI: *Mokuzai Gakkaishi (J. Jpn. Wood Res. Soc.)*, **42**(7), 659–667 (1996) (in Japanese with English Summary).

The mechanism involved in the rapid curing of cement-bonded particleboard (CBP)

with sodium hydrogen carbonate (NaHCO_3) as an additive under steam injection pressing was investigated. The effects of steam pressure (SP), steam injection time (SIT), and curing conditions, that is, wrapped curing or water-soaked curing on the board properties were examined. The mechanism of the rapid curing of cement was evaluated by the results of scanning electron microscopic (SEM) observations and X-ray diffraction analysis.

Results confirmed that NaHCO_3 plays an important role as an initial fortifier for CBPs. In the case of 15–20% NaHCO_3 contents, it was observed that there was an increase in the initial board strength at a shorter pressing time. However, much calcium carbonate (CaCO_3) was produced. CaCO_3 covered the cement clinker and inhibited the hydration process of the cement. Because cement hydration did not continue further, greater mechanical strength in the final condition was not attained on the other hand, CBPs with 2.5–5% NaHCO_3 contents had less products of CaCO_3 which continued the hydration process under the water-soaked curing condition. However, the final mechanical strengths of CBPs produced at a total pressing times of less than 12 minutes were not as strong as those produced commercially. This suggests that further investigation is needed to develop CBPs with better properties.

Rapid curing of cement-bonded particleboard III. Effects of sodium hydrogen carbonate and some cement hardening, W. NAGADOMI, Y. KUROKI, D.A. EUSEBIO, L. MA, S. KAWAI and H. SASAKI: *Mokuzai Gakkaishi (J. Jpn. Wood Res. Soc.)*, **42**(8), 762–768 (1996) (in Japanese with English Summary).

To improve the properties of cement-bonded particleboard (CBP) produced with sodium hydrogen carbonate (NaHCO_3) applying steam injection pressing, a series of experiments were conducted with the addition of various cement hardening accelerators such as magnesium chloride (MgCl_2), calcium chloride (CaCl_2), aluminum chloride (AlCl_3), ferric chloride (FeCl_3), and ammonium chloride (NH_4Cl). Results revealed that MgCl_2 was the most effective accelerator for cement hydration which imparted a favorable effect on the mechanical properties and thickness swelling of the boards. On the other hand, it can be speculated that MgCl_2 adversely affected the linear expansion (LE) and linear shrinkage (LS). The optimum additions of NaHCO_3 and MgCl_2 in the series of experiments were found to be at 2.5% and 2.0%, respectively.

Rapid curing of cement-bonded particleboard IV. Sodium silicate as a fortifier during steam injection pressing, W. NAGADOMI, Y. KUROKI, D.A. EUSEBIO, L. MA, S. KAWAI and H. SASAKI: *Mokuzai Gakkaishi (J. Jpn. Wood Res. Soc.)*, **42**(8), 769–775 (1996) (in Japanese with English Summary).

To improve the properties of cement-bonded particleboard (CBP) produced by applying steam injection pressing, sodium silicate (Na_2SiO_3) was added to ordinary portland cement (OPC) as a fortifier. Some CBPs also were produced using only Na_2SiO_3

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or sodium hydrogen carbonate (NaHCO_3) as fortifiers while magnesium chloride (MgCl_2) was added as an accelerator for cement hydration. The effects of varying the contents of Na_2SiO_3 , the methods of curing, the soaking times of solutions, the contents of MgCl_2 , the steam pressures (SP), and the total pressing times (TPT) were evaluated.

It was found that Na_2SiO_3 was more effective than NaHCO_3 as a fortifier with or without the addition of MgCl_2 . CBPs with Na_2SiO_3 had a favorable effect on linear dimensional stability even without the presence of MgCl_2 considering the results of mechanical properties and dimensional stability tests, optimum conditions can be achieved from CBPs with 5% Na_2SiO_3 and without the addition of MgCl_2 for the water soaking curing of 14 days. The most favorable SP and TPT were found to be at 1.5 kgf/cm^2 and 12 mins, respectively.

Manufacture and properties of composite fiberboards (III), Properties of three-layered bamboo-wood composite boards and stress analysis by the finite element method, M. ZHANG, T. KAWASAKI, P. YANG, T. HONDA and S. KAWAI: *Mokuzai Gakkaishi (J. Jpn. Wood Res. Soc.)*, **42**(9), 854–861 (1996) (in Japanese with English Summary).

Wood fibers (WF), bamboo fibers (BF), and thin bamboo strands (BS) were used to manufacture three types of composite boards; composite boards (BF-WF) made from mixing BF and WF, three-layered composite boards (BF/WF/BF) with BF as the face material and WF as the core material, and three-layered composite boards (BS/WF/BS) with BS and WF as face and core materials, respectively. The density profile along the thickness of each kind of composite board was examined at various mixing and constituent ratios. The influences of the mixing and constituent ratios and the density profiles on the properties of each type of board were examined. The normal stress distributions of the BS/WF/BS boards were analyzed numerically by the Finite Element Method (FEM).

Water resistances and dimensional stabilities of BF-WF boards increased greatly with increasing BF to WF mixing ratios. For the BF/WF/BF boards with a comply structure, water resistances and dimensional stabilities increased greatly with increasing amount of BF in the faces of the boards. On the other hand, the specific MOR (moduli of rupture) and MOE (moduli of elasticity) of the BS/WF/BS boards with a sandwich structure were greater compared to those of commercial plywood and other composite boards. This was due to the orientation of the BS in the faces of the boards. In addition, the results of the FEM analysis clearly showed that the normal stresses and their distributions in the BS/WF/BS boards differed remarkably with varying face to core ratios.

Rapid curing of cement-bonded particleboard V. Mechanism of strength development with fortifiers and accelerators during steam injection pressing, W. NAGADOMI, Y. KUROKI, D.A. EUSEBIO, L. MA, S. KAWAI and H. SASAKI: *Mokuzai Gakkaishi (J. Jpn. Wood Res. Soc.)*, **42**(10), 977–984 (1996) (in Japanese with English Summary).

This report describes the mechanisms involved in the rapid curing of cement-bonded particleboard (CBP) during steam injection pressing when sodium hydrogen carbonate (NaHCO_3) and sodium silicate (Na_2SiO_3) were added as fortifiers, and magnesium chloride (MgCl_2) as an accelerator of cement hydration. In this study, a scanning electron microscopic (SEM) investigation and an X-ray diffraction analysis were made.

It was revealed that the initial hardening of cement was brought about by the production of calcium carbonate (CaCO_3) when NaHCO_3 was added. On the other hand, amorphous calcium silicate hydrate (CSH) and cementation of SiO_2 gel occurred when Na_2SiO_3 was used as a fortifier. It was further confirmed that MgCl_2 was a more effective accelerator for cement hydration than was calcium chloride. It was revealed that the hydration of cement was brought about by the production of CSH Type IV when MgCl_2 was added.

Curing behavior of wood adhesives under high-pressure steam III. Bonding strength of phenolic resin, K. UMEMURA, H. TANAKA, Y. MIZUNO and S. KAWAI: *Mokuzai Gakkaishi (J. Jpn. Wood Res. Soc.)*, **42**(10), 985–991 (1996)

This paper deals with the bonding performance of phenol-formaldehyde (PF) resin in steam-injection heating at 160°C ; the effects of additives and steam-injection time on bonding strength were studied. In addition, suitable bonding condition for PF resin in steam-injection heating was investigated. The results are summarized as follows: as steam-injection time increased, the bonding strengths of 3-ply plywood, glued with a neat PF resin and wheat flour extended PF resin, after cyclic boiling treatment decreased. The reason seemed that swelling, dilution, and over-penetration of PF resin took place in long steam-injection heating. With sodium carbonate-added resin, the bonding strength increased gradually with increasing steam-injection time. To improve the bonding strength in a short heating time, intermittent steam-injection heating was tried. When a neat resin and sodium carbonate-added resin were used, the bonding strengths were improved dramatically. Therefore, intermittent steam-injection heating was effective for the development of the bonding strength of PF resin.

Manufacture of wood composites using lignocellulosic materials and their properties I. Improvement of bagasse particleboards dimensional stabilities by using a steam-injection press, M. ZHANG, S. KAWAI, S. YUSUF, Y. IMAMURA and H. SASAKI: *Mokuzai Gakkaishi (J. Jpn. Wood Res. Soc.)*, **42**(11), 1082–1089 (1996) (in Japanese with English Summary).

Steam-injection pressing was used to manufacture bagasse particleboards with various steam injection durations to improve the dimensional stabilities of the boards. Control bagasse particleboards were manufactured by using normal hot pressing. In addition to the effects of injection pressure and duration on the mechanical properties, its effects on the

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water and moisture resistance properties, as well as fungal and termite resistances of the boards were also investigated.

The mechanical properties of the boards fabricated using a steam-injection press were found to be slightly less than those manufactured by a hot press. However, the thickness swelling after water-soaking decreased greatly with increasing injection pressure and time. Boards fabricated by the steam-injection press had better dimensional stability. It is clear that bagasse particleboards pressed with a steam-injection press have better hygroscopicity; although the moisture regain (equilibrium moisture content) of the boards was not significantly different from the normal hot press. The thickness variations recorded in the adsorption and desorption processes were comparatively smaller.

Bagasse particleboards were assumed to decay more easily than conventional wood particleboards. The decay resistance of steam-injection-pressed bagasse particleboards was reduced greatly with increasing injection pressure and time, especially in the case of the brown rot fungus, *Tyromyces palustris* Mur. A similar trend of reduction in resistance against termites was also detected in a choice-feeding test using *Coptermes formosanus* Shiraki.

Rapid curing of cement-bonded particleboard with silica fume I. Effects of an additive for cement hydration during steam injection pressing, W. NAGADOMI, Y. KUROKI, S. KAWAI and H. SASAKI: *Mokuzai Gakkaishi (J. Jpn. Wood Res. Soc.)*, **42**(11), 1090–1097 (1996) (in Japanese with English Summary).

To improve the properties of cement-bonded particleboard (CBP) produced by steam injection pressing, silica fume was added to ordinary portland cement (OPC) as an additive for cement hydration. CBPs were also produced by adding sodium silicate (Na_2SiO_3) as a fortifier. The effects of varying the silica fume content, curing methods, and the total pressing time (TPT) on the properties of the CBP were evaluated.

It was found that silica fume was more effective as an additive for cement hydration with the addition of Na_2SiO_3 . Silica fume as an additive improved the mechanical properties of CBPs by accelerating the cement hydration and filling the gap in the cement structure considering the results of mechanical properties and dimensional stability tests, the optimum conditions can be achieved from CBPs with 15% silica fume for 14 days of water-soaked curing. The most favorable TPT was 12 minutes.

Rapid curing of cement-bonded particleboard with silica fume II. Effects of autoclave curing on cement hydration, W. NAGADOMI, Y. KUROKI, S. KAWAI and H. SASAKI: *Mokuzai Gakkaishi (J. Jpn. Wood Res. Soc.)*, **42**(12), 1202–1210 (1996) (in Japanese with English Summary).

To improve the properties of cement-bonded particleboard (CBP) produced by applying steam injection pressing, silica fume was added to ordinary portland cement

(OPC) as an additive for the rapid cement hydration. Then the autoclave curing method was applied. Five percent of sodium silicate (Na_2SiO_3) also was added as a fortifier. The effects of varying the silica fume content, the total pressing time (TPT), and the autoclave curing temperature were evaluated.

It was found that silica fume was effective as an additive for rapid cement hydration with the addition of Na_2SiO_3 . Silica fume as an additive improved the mechanical properties of CBPs by accelerating cement hydration and filling the gaps in the cement structure. Furthermore, autoclave curing applied with silica fume improved the dimensional stabilities of CBPs by eliminating the product of ettringite. Considering the results of mechanical properties and dimensional stabilities, optimum conditions can be achieved for CBPs with 20–25% of silica fume at over 135°C of autoclave curing temperature. The most favorable TPT was 12 minutes. The production period of CBPs was much shortened by autoclave curing.

Development of compressed wood fasteners for timber construction I. Mechanical properties of phenolic resin impregnated compressed laminated veneer lumber, K. NAKATA, H. SUGIMOTO, M. INOUE and S. KAWAI: *Mokuzai Gakkaishi (J. Jpn. Wood Res. Soc.)*, **43**(1), 38–45 (1997) (in Japanese with English Summary).

To develop compressed wood fasteners for timber Construction, rotary-cut veneers of sugi (*Cryptomeria japonica* D. Don) were impregnated with low molecular weight phenolic resin (PF) and pressed into laminated veneer lumber (LVL) of parallel laminates (P-type) or crossbanded laminates (C-type) by hot pressing. The mechanical properties for bending, compressive and horizontal shearing of the compressed LVL were determined. The results were as follows

1) PF concentrations of about 15% was appropriate to obtain both great strength and dimensional stability. It was estimated that the mechanical properties of the P-type with a density of 1.3 g/cm³ were 2–7 times as much as those of glued-laminated timbers of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco).

2) The mechanical properties of the C-type decreased with increasing numbers of crossband veneers, and those of crossbanded laminates, quite like the plywood, were about 70% of those of the P-type. The mechanical properties of the C-type having various laminated patterns could be calculated on the basis of both those of the P-type and the positions of the crossband veneers.

3) The changes of the mechanical properties with changes of the grain angle of the compressed LVL could be calculated using a Hankinson-type formula. For the P-type the mechanical properties, except for the compressive strength, decreased considerably with increasing grain angle, but for the C-type no mechanical properties were changed very much by changes in the grain angle, but they were greater than those of the P-type at grain angles

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of more than 30 degrees.

4) C-type had great horizontal shearing strength for edge-wise loads and a very ductile behavior at grain angles of more than 30 degrees. Therefore, this type of compressed LVL is suitable for fasteners.

Manufacture of wood composites using lignocellulosic materials and their properties II. Manufacture of high-performance bagasse composite boards and their stress analysis by the finite element method, M. ZHANG, S. KAWAI, P. YANG and T. HONDA: *Mokuzai Gakkaishi (J. Jpn. Wood Res. Soc.)*, **43**(4), 310–317 (1997) (in Japanese with English Summary).

Bagasse strands and particles were prepared to manufacture three-layered bagasse composite boards by using a steam-injection press. The influences of the face strands to core particles ratios and the injection pressure and duration on the properties of the boards were examined. The stress distributions of the composite boards were analyzed numerically by using the Finite Element Method (FEM).

The mechanical properties of the boards, that is, moduli of rupture (MOR) and elasticity (MOE), MOR and MOE retentions in wet conditions, and wood screw retaining forces, increased greatly with increasing face to core ratios. This was due to the orientation of the strands in the faces of the boards. For the dimensional stabilities of the boards, the thickness swellings of boards fabricated using the steam-injection press with 3 min injection at 180°C, were remarkably smaller than those fabricated with 7 min injection at 160 °C. However, a reverse trend was observed in the linear expansions (LE) of the boards, which was reduced greatly with increasing face to core ratios.

In addition, the concentrations and degradations of stresses at the loading and supporting points of the boards were indicated clearly in the results of the FEM analyses. It is clear that the shear stresses at the face/core interface were affected greatly by the face to core constituent ratios.

Manufacture of wood composites using lignocellulosic materials and their properties III, Properties of bamboo particleboards and dimensional stability improvement by using a steam-injection Press, M. ZHANG, S. KAWAI, S. YUSUF, Y. IMAMURA and H. SASAKI: *Mokuzai Gakkaishi (J. Jpn. Wood Res. Soc.)*, **43**(4), 318–326 (1997) (in Japanese with English Summary).

Three types of raw materials from different parts of bamboo, that is, the outer layer, the inner layer, and whole bamboo were used to manufacture particleboards. The influences of resin contents and particle sizes on the properties of the boards were examined. The effects of steam-injection pressing on dimensional stability improvements, and the fungal and termite resistances of the boards were also investigated.

The mechanical properties (moduli of rupture (MOR) and elasticity (MOE) in dry and

wet conditions, internal bond strengths (IB), hardnesses), and physical properties (thickness swelling (TS), linear expansion (LE), hygroscopic isotherm, and TS in different relative humidities) of the boards were determined in accordance with the JIS (Japanese Industrial Standard). The properties of the boards were influenced largely by the use of different bamboo components, various resin contents and particle sizes. It is clear that boards fabricated with a steam-injection press have better water resistances and hygroscopicities. In addition, the results of fungal and termite resistance tests showed that bamboo particleboards decay more easily than the conventional wood particleboards, while the same degrees of resistance against termites (*Coptermes formosanus* Shiraki) were observed.

Manufacture and properties of hollow cylindrical LVL, H. SASAKI, H. YAMAUCHI, I. MIURA, Y. IJIMA, A. KOIZUMI and S. KAWAI: *Proc. of the International Wood Engineering Conference '96*, p. 3-538/3-540, Oct. 28-31, New Orleans, USA (1996).

The present paper aims to assess the practicability of a new technology for conversion of veneer residues into hollow cylindrical LVL for structural use. A spiral winding method that has been used in the manufacture of paper tubes was employed and modified to be able to wind veneer tapes in this study. An endless cedar and pine veneer tapes of 150 mm width (fiber direction) and 2.5 mm thicknesses were prepared. These tapes were reinforced by sewing with polyester thread across the grain. The tape was wound spirally on a steel mandrel of 250 mm diameter in clock wise and counter clock wise directions alternately to manufacture 8-ply to 16-ply LVL cylinders of 3,500 mm length using honeymoon-type resorcinol resin and aqua-polymer isocyanate resin adhesive. Pressure of 0.5 MPa was applied for around 7 mm by tightening up with an elastic pressure belt. The inner space of the LVL column was filled with special light-weight molds of waste paper-polyethylene mixture for the radial reinforcement. To ascertain the effect of interlocked grain of veneer on the modulus of elasticity of the laminates, theoretical and experimental investigations were made. The flexural properties were tested by four points loading system. The bending rigidity, ultimate bending moment and deformation of the cross-sectional shape of the cylinders were measured. The moduli of elasticity in bending of the cylinders with and without the filler were almost same at 5 GPa.

Bonding strength improvement of formaldehyde resin adhesives under high-pressure steam, K. UMEMURA, Y. MIZUNO and S. KAWAI: *Proc. of the Third Pacific Rim Bio-Based Composites Symposium*, p. 224-230, Dec. 2-5, Kyoto, Japan (1996).

The effects of additives and steam-injection times on the bond strength development of phenol-formaldehyde (PF) resin in steam-injection heating at 160°C were studied. In addition, suitable bonding condition for PF resin in steam-injection heating was investigated. The results are summarized as follows: as the steam-injection time increased, the bond strengths of 3-ply plywood, glued with a neat PF resin and wheat flour extended PF

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resin increased to some degree and then decreased. For sodium carbonate-added PF resin, the bond strength showed the maximum value in the early stage and then decreased gradually with the steam-injection time. The reason for the decrease of the bond strength seemed to be the formation of starved joint in the glue line in long steam-injection heating. To improve the bond strength, intermittent steam-injection heating was applied. When sodium carbonate-added resin was used, the bond strengths were improved dramatically. Therefore, the addition of sodium carbonate and intermittent steam-injection heating were effective for the development of the bond strength of PF resin under steam-injection heating.

Bark-cement composites, D.A. EUSEBIO, H. YAMAUCHI, H. SASAKI, and S. KAWAI: *Proc. of the Third Pacific Rim Bio-Based Composites Symposium*, p. 274–282, Dec. 2–5, Kyoto, Japan (1996).

The development of new process technologies to utilize agro-forest Wastes for composite production is an active area of research in the field of inorganic bonded boards. Comparatively however, bark has received a relatively little attention as to its potential use for cement-bonded board (CBB) manufacture.

In this paper, the possibility of using bark of Japanese cedar for CBB was studied. In order to understand the basic principles that may take place in cement hydration and strength development of bark-cement mixtures, the hydration temperature and compressive strength were determined. In addition, CBBs were produced by the conventional- and steam injection pressing methods considering several production variables.

Results showed that the hydration temperature of cement paste was retarded by the addition of bark but was improved by the addition of MgCl_2 and Na_2SiO_3 . The compressive strength of hydrated bark : cement : water mixtures without any chemical accelerator was similar to those with MgCl_2 and Na_2SiO_3 but were smaller when NaHCO_3 was added. The properties of the boards produced by conventional pressing improved when MgCl_2 was added but not with the addition of Na_2SiO_3 . Rapid curing of bark-cement boards was achieved with the addition of Na_2SiO_3 and the introduction of SIP.

Hybrid composites from wood carbon fibers, O.R. PULIDO, L-F. MA, Y. NAKANISHI, H. OGAWA and S. KAWAI: *Proc. of the Third Pacific Rim Bio-Based Composites Symposium*, p. 310–318, Dec. 2–5, Kyoto, Japan (1996).

The strength and fire resistance of CFRP-overlaid composite boards with sugi chip or bark cores were tested. Results showed increase in moduli of rupture and elasticity of overlaid boards compared to those without overlays. The fire resistance of boards increased significantly especially those with sugi bark cores. The time to burn through of CFRP-overlaid sugi barks were longer than those of gypsum bonded boards from the same materials.

The hybrid composites gave higher strength in bending than the core panels but less

than those of carbon fiber reinforced preregs. Depending on the type of core, failure occurred either in shear at the core, delamination at the wood-CF interface, compressive failure of the CF surface, or their combinations. The initial results showed that the properties of wood composites can be easily improved when combined with other materials. Hopefully, a new boundary area of research on wood and carbon fiber hybrid composites could be established.

Manufacture and properties of hollow cylindrical LVL, H. SASAKI, H. YAMAUCHI, I. MIURA, Y. IJIMA, A. KOIZUMI and S. KAWAI: *Proc. of the Third Pacific Rim Bio-Based Composites Symposium*, p. 335–339, Dec. 2–5, Kyoto, Japan (1996).

The present paper aims to assess the practicability of a new technology for conversion of veneer residues into hollow cylindrical LVL for structural use. A spiral winding method that has been used in the manufacture of paper tubes was employed and modified to be able to wind veneer tapes in this study. An endless cedar and pine veneer tapes of 150 mm width (fiber direction) and 2.5 m thicknesses were prepared. These tapes were reinforced by sewing with polyester thread across the grain. The tape was wound spirally on a steel mandrel of 250 mm diameter in clock wise and counter clock wise directions alternately to manufacture 8-ply to 16-ply LVL cylinders of 3,500 mm length using honeymoon-type resorcinol resin and aqua-polymer isocyanate resin adhesive. Pressure of 0.5 MPa was applied for around 7 mm by tightening up with an elastic pressure belt. The inner space of the LVL column was filled with special light-weight molds of waste paper-polyethylene mixture for the radial reinforcement. To ascertain the effect of interlocked grain of veneer on the modulus of elasticity of the laminates, theoretical and experimental investigations were made. The flexural properties were tested by four points loading system. The bending rigidity, ultimate bending moment and deformation of the cross-sectional shape of the cylinders were measured. The moduli of elasticity in bending of the cylinders with and without the filler were almost same at 5 Pa.

Manufacture and properties of high performance boards, M. ZHANG, S. KAWAI, W.E. DING and J. KWON: *Proc. of the Third Pacific Rim Bio-Based Composites Symposium*, p. 346–352, Dec. 2–5, Kyoto, Japan (1996).

Fibers, particles and strands from wood, bamboo, and bagasse were used to manufacture three-layered high performance composite boards with various combinations, namely, hinoki strands/mixture of sugi and hinoki particles (HS/WP/HS); bamboo strands/lauan fibers (BS/LF/BS); and bagasse strands/bagasse particles (B'S/B'P/B'S). In all cases, the oriented strands composed the faces, while the particles or fibers constituted the core of the boards. The conventional hot pressing (160°C) and steam-injection pressing (160°C and 180°C) methods were used, with isocyanate resin as the adhesive. The mechanical and physical properties of the boards were evaluated based on the Japanese

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Industrial Standard (JIS).

The moduli of rupture (MOR) and elasticity (MOE) of HS/WP/HS, BS/LF/BS, and B'S/B'P/B'S boards increased greatly with increasing face to core constituent ratios. The specific MOR and MOE of the BS/LF/BS boards were the highest among all the combinations, exceeding those of the commercial plywood. This could be due to the fact that bamboo itself has higher mechanical strength compared to wood and bagasse.

The B'S/B'P/B'S boards manufactured using steam-injection pressing had the best dimensional stability compared to the other boards. The effects of steam injection pressure on the board dimensional stabilities were greater than the injection duration.

Strength and dimensional stability of cement-bonded composites manufactured by rapid curing method with sodium silicate, L-F. MA, O.R. PULIDO, H. SASAKI, S. KAWAI, L-M. YE and X-J. YU : *Proc. of the Third Pacific Rim Bio-Based Composites Symposium*, p. 484–489, Dec. 2–5, Kyoto, Japan (1996).

Residues from the processing of sugi (*Cunninghamia lanceolata*) grown in China and three kinds of cement, namely ordinary Portland cement #525 and #425, and white Portland cement #425 were used as raw materials in the manufacture of cement bonded composite boards. Sodium silicate, Na_2SiO_3 , was added as a fast curing additive. Boards were produced using both cold pressing and hot pressing methods. The influence of the quantity of Na_2SiO_3 additive, temperature of hot platen, pressing time, water/cement ratio, cement/wood ratio, type of cement, and particle size on the MOR and MOE of the boards were determined. The best conditions are 10% addition of Na_2SiO_3 , 95°C platen temperature, 12 minutes pressing time, water/cement ratio of 0.6, cement/wood ratio of 2.6 which resulted to board MOR of 10 MPa. This shows that cement bonded wood composites can also be produced by hot pressing.

Properties of glass fiber reinforced laminated veneer lumber produced with a continuous steam injection press and lamination effect, Y. YANAGAWA, S. KAWAI and H. SASAKI : *Proc. of the Third Pacific Rim Bio-Based Composites Symposium*, p. 491–499, Dec. 2–5, Kyoto, Japan (1996).

Glass fiber net reinforced and non reinforced sugi (*Cryptomeria japonica* D. Don) laminated veneer lumber (LVL) were produced using a continuous press with steam injection heating devices on both sides. Their mechanical properties were evaluated, and the effect of lamination were also investigated by flexural testing of LVL, three ply glulam and solid lumber. The results are summarized as follows ;

1) The modulus of rupture (MOR) of glass fiber reinforced LVL was more than that of the control LVL in flatwise bending. In edgewise bending, as the number of nets increased, The MOR increased. The modulus of elasticity (MOE) did not increase remarkably with the incorporation of the nets into the LVL.

2) The splitting strength of the reinforced LVL increased with the number of nets, and the LVL fractured slowly.

3) In the creep test under fire, the fire endurance properties of the reinforced LVL improved remarkably with increasing number of nets.

4) The standard deviations (SD) of the MOE of laminated members were reduced by increasing the number of laminations. The SD of the MOE of laminated members could be predicted from the average value and SD of solid lumber.

Development of compressed wood fasteners for timber construction, K. NAKATA, H. SUGIMOTO, M. INOUE and S. KAWAI: *Proc. of the Third Pacific Rim Bio-Based Composites Symposium*, p. 524–532, Dec. 2–5, Kyoto, Japan (1996).

In order to develop the compressed wood fasteners for timber construction, low-molecular weight phenolic resin (PF) impregnated rotary-cut veneers of sugi (*Cryptomeria japonica* D. Don) were pressed into laminated veneer lumber (LVL) of parallel laminates (P-type) or crossband laminates (C-type) by hot pressing. As glulam and compressed wood plates can be drilled easily at the same time, both the executive operation efficiency and the accuracy of joints were improved. The mechanical properties of compressed LVL were determined. These new joints were compared with drift-pinned joints with steel plates which are widely used currently. The results were as follows;

1) The average values of modulus of elasticity, modulus of rupture and compressive strength of P-type with a density of 1.3 g/cm^3 were 25 GPa, 240 MPa and 145 MPa, respectively. The PF weight gain of about 25% was appropriate for obtaining both high strength and good dimensional stability.

2) The mechanical properties of P-type, except for the compressive strength, decreased considerably with increasing grain angle. However the mechanical properties of C-type were not affected much by the grain angle, and were greater than those of P-type at the grain angle above 30 degrees.

3) The maximum bearing strength and the initial stiffness of the compressed LVL increased with increasing density, but both of these values for the P-type impregnated with 20% PF concentration were lower than those with 15%. P-type with above 15% PF concentration showed brittle failure, but C-type and P-type with less than 10% PF concentration showed very ductile behavior.

4) The tension-type lateral strength tests of drift-pin joints were conducted, where 1–4 C-type compressed LVL plates or steel plates were inserted into the glulam of Douglas fir. By using three compressed LVL plates, the lateral resistance of the joint was the same as when 2–3 steel plates were used, and the behavior of the rupture was very ductile.

Properties of composite boards in relation to processing conditions and density profiles, W.E. DING and S. KAWAI: *Proc. of the First International Wood Science Seminar*, p. 7,

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Dec. 6–7, Kyoto, Japan (1996).

The density of reconstituted wood-based panels is not uniform in the thickness (vertical) direction, but varies through the thickness. The typical density profile of flat-platen pressed boards resembles a U-shape, where the highest density is formed near the board surfaces, with the lowest density in the core.

The density profile of reconstituted panels is affected mainly by the furnish characteristics (e.g, configuration, compressibility, moisture content and its distribution) and hot pressing conditions (including type, temperature, closing speed, pressure and duration).

Some properties of the board, in particular the bending strength, are enhanced by the presence of higher peak density near the surfaces, whereas the internal bond and interlaminar shear are adversely affected by this density distribution. However, a steep density gradient does not improve the modulus of rupture as the horizontal shear-failure occurs before the specimen fails in bending. Besides, the thickness swelling and water absorption of the board also tend to deteriorate in steep density profile. The internal bond was found to exhibit a linear relationship with the minimum density in the thickness direction of the board.

The effects and control of density profile of reconstituted panels for improved board properties have been of interest to the wood science researchers for more than half a century. Nevertheless, only the qualitative relationships between the board density profile and their properties have been established so far. In this study, attempts are made to define the specific correlations between the selected raw material characteristics, hot pressing conditions, the board density profile and the properties of the composite boards fabricated.

Steam injection pressing technology. The effects and its application to the composite wood production, S. KAWAI and H. SASAKI: *Proc. of the First International Wood Science Seminar*, p. 9, Dec. 6–7, Kyoto, Japan (1996).

Steam pressing technology has attracted special interest recently because of its two significant effects on the physical processing of wood based materials, i.e., 1) the rapid curing of adhesives in composite wood production, and 2) the dimensional stability of compressed wood products.

This new process involves injecting high-pressure steam through perforated platens into the composite during hot-pressing. The steam diffuses among the wood elements and supplies heat energy to stimulate the rapid cure of resin adhesive. As a result, the pressing time is much shorter than by conventional hot-platen pressing. The process can be applied not only to the particleboard (PB) and fiberboard (FB) production but also to the laminated veneer lumber (LVL) production. It can also be applied to the rapid curing process of cement bonded PB/FB together with certain accelerators for the cement hydration.

The authors have developed two different types of continuous presses with steam-injection device in test plant scale for the continuous production of 100 mm thick low-density PB/FB, their composite structural panels and LVL.

It has also been pointed out that steam-injection pressing in the manufacture of PB results in a significant reduction in the thickness changes of the boards. This effect is now expanded to the treatments for the fixation of compressive deformation or compressive set in any form of compressed products such as compressed wood, compressed LVL, OSB, PB and MDF. In this respect, the high pressure steam needs to be maintained during pressing, therefore, a sealed or self-sealed system is required.

Isocyanate-inorganic bonded composites IV. Factors affecting board properties by steam injection pressing, D. EUSEBIO, S. KAWAI and H. SASAKI: *Proc. of the First International Wood Science Seminar*, p. 10, Dec. 6–7, Kyoto, Japan (1996).

Isocyanate-cement bonded particleboard with a target density of 1.2 g/cm^3 were produced with the introduction of steam injection pressing (SIP) at a steam injection time (SIT) and steam pressure of 3 secs and 1.25 kgf/cm^2 , respectively. The effect of varying the wood : cement (Wo : Ce) ratio at 3, 5, 10 and 15 mins of total pressing time (TPT) and isocyanate (IC) resin content on the properties of the boards were determined. Results revealed that with the incorporation of IC resin and introduction of SIP, cement bonded particleboard could be handled immediately after a few minutes of pressing. From the relationships between Wo : Ce ratio and TPT, it showed that both mechanical and physical properties were governed more by varying the Wo : Ce ratio rather than by the effect of different TPTs. On the other hand, the effect of increasing the IC resin content varied depending on the Wo : Ce ratio. The most favorable outcome was obtained at 6% IC resin content at a Wo : Ce ratio of 1.0 : 1.0.

Rapid production of thermosetting cement bonded particleboard by steam injection pressing, B. SUBIYANTO and S. KAWAI: *Proc. of the First International Wood Science Seminar*, p. 92–98, Dec. 6–7, Kyoto, Japan (1996).

Shortening pressing time of thermosetting cement-bonded particleboard by steam injection pressing were determined. Albizzia (*Pareserienthes falcataria* (L) Nielson) and mixture Japanese hinoki (*Chamaecyparis obtusa* Endl.) and sugi (*Cryptomeria japonica* D. Don) was used as raw materials. For albizzia wood particles, the experiment was aimed at observing effect of density on physical and mechanical properties of cement bonded-particleboard using seal system of steam injection pressing. In separate experiment, the effects of seal and non-seal system, steam pressure on physical and mechanical properties of cement bonded-particleboard prepared from mixture of sugi and hinoki wood species as raw material was determined.

Thermosetting cement-bonded particleboard prepared from albizzia and mixture of

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hinoki and sugi wood particles can be produced with very short pressing time. Using albizzia wood species, low density of cement-bonded particleboard was more better than that of high density, due to delamination of high density cement-bonded particleboard was observed. Physical and mechanical of thermosetting cement bonded-particleboard prepared from mixture of hinoki and sugi wood particles showed more better than that of albizzia wood particles. The optimum steam injection pressure with seal system was 2.5 kgf/cm² showed the best physical and mechanical properties of thermosetting cement bonded-particleboard prepared by mixture of sugi and hinoki.

Toward the new generation of bio-based composite products, S. KAWAI : *Proc. the Third Pacific Rim Bio-based Composites Symposium*, p. 1-4, Dec. 2-5 Kyoto, Japan (1996).

The development of wood composite products was reviewed and the future research works were discussed: lumber composites such as glulam, LVL, Parallam, OSL are unidirectionally highly oriented materials and the newer products are composed of smaller elements. This trend reflects the exhaustion of forest resources and the efforts made to improve the production yield, as well as the trend toward factory automation. From the viewpoint of material performance, the newer products have a higher reliability. In such lumber composites, the end-joints of the elements are considered to be the defect which is the determining factor for the mechanical strength. The theoretical analysis such as fracture mechanics approach on the relationship between the mechanical strength and the element size is needed for the development of new generation of lumber composite products.

In panel products, an advanced OSB with thin strands is now in the process of being developed in order to achieve improved surface properties and dimensional stability in the thickness direction. Oriented MDF blended with various types of fibers will be realized in the near future. A sandwich panel made up of two stiff, strong faces with a light-weight core is a promising material: composite structural panel composed of veneers on both surfaces and thick low-density fiberboard or particleboard in the core has proved to have high performance in mechanical strength, dimensional stability, and thermal insulation. The cement bonded particleboard or fiberboard is an unique wood composite for exterior siding due to the remarkable features of its high resistance against fire, weather, termite and fungal attacks. Rapid curing of cement bonded particleboard by applying steam-injection pressing and incorporation of certain cement setting accelerators has been of interest in recent years. In addition, cement bonded OSB has also been investigated for improved mechanical strength and lower density. The research and development of new processing technology to convert non-wood ligno-cellulosic fibrous materials, agricultural wastes, and recycled wood into panel products is highly necessary to ensure the sustainable utilization of the existing forest resources.

A new concept on the environmental aspects needs to be incorporated in the

development of material science for the new generation of bio-based composite products; a concept of life-cycle cost including environmental impacts as well as material and energy consumptions throughout the life cycle of the products or the systems is gaining more importance. One popular approach used today is life cycle assessment (LCA).

Manufacture of wood based materials (II), S. KAWAI: *Mokko Kikai (Wood Machinery)*, No. **172**, 13–16 (1996) (in Japanese).

Development of wood based-materials is reviewed. Recent progress of composite lumber products, production technology and machinery is outlined.

Manufacture of wood based materials (III), S. KAWAI: *Mokko Kikai (Wood Machinery)*, No. **173**, 13–16 (1996) (in Japanese).

Development of wood based-materials is reviewed. Recent progress of oriented strand board and particleboard, production technology and machinery is outlined.

Manufacture of wood based materials (IV), S. KAWAI: *Mokko Kikai (Wood Machinery)*, No. **174**, 16–19 (1996) (in Japanese).

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Two topics was introduced as good examples of utilizing plantation grown Sugi trees to large scale timber constructions. One of which was the case of glulam arch bridge made of plantation grown Sugi in Ehime prefecture. The second example is Akita-Oodate Dome made of Akita Sugi which was taken from northern part of Akita prefecture.

Timber bridges in overseas, K. KOMATSU: *Doboku Sekkou (Civil Engineering Journal)*, **38**(5), 49–55 (1977) (in Japanese).

Examples and case study on timber bridges built in overseas recently were reviewed.

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ABSTRACTS

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Timber joints being used in timber structures were introduced and their durability was discussed.